Shells and Stones:
A Functional Examination of the Tuamotus Adze Kit

Jonathon Klem

Jonathon Klem, M.A. Candidate, Department of Anthropology, University of Hawai'i at Manoa, Honolulu, HI 96816 (jklem@hawaii.edu)

Abstract

Based on a study of functional variation in 84 stone and 192 shell adzes from the Bishop Museum Tuamotus adze collection, this paper argues that the Paumotu, or the inhabitants of the Tuamotus, maintained trade with the high volcanic islands of Central East Polynesia in part to acquire resources that did not naturally occur within the Tuamotus. This project relies upon experimental research conducted on Polynesian adzes (Best, 1977; Turner 2000, 2005), and morphological typologies (Shipton et al., 2016), and emphasizes the importance of material type and intended function as the driving forces in the production of the East Polynesian adze kit. The author found that the Tuamotus Adze Collection exhibits significant variation for several functional characteristics identified by previous studies along the lines of material type. These differences in function align with Turner's (2000) functional adze typology, with the shell adzes filling the role of Turner's Type A, while the stone adzes are spread between the Type A, Type B, and Type C adzes. Because each of these functional types are fundamental in canoe construction, the observed differences between the shell and stone adzes in the Tuamotus Adze Collection suggest that the acquisition of high-quality basalt from the nearby high volcanic islands in Central East Polynesia was critical to the maintenance of the ship-building industry present within the Tuamotus.

Keywords: Central East Polynesia, exchange, prehistoric seafaring, Tuamotus, Society Islands, tool function, adzes

1. Introduction

The Tuamotus are a series of 75 atolls south of the Marquesas Islands and northwest of the Society Islands in Central East Polynesia. Central East Polynesia, hereafter abbreviated as CEP, is the area including the Society, Marquesan, Tuamotu, Austral, and Cook Island groups. Contact between the Tuamotus and the nearby Society and Marquesan island chains is well documented in both the historical and archaeological record. The Tuamotus, being coral atolls, lack the volcanic basalt sources found in other archipelagoes. Therefore, the Polynesian settlers of these atolls regularly imported basalt adzes from several different archipelagoes both within Central East Polynesia and beyond (Collerson and Weisler, 2007: 1907). According to oral and historical evidence, the Tuamotus also supplied the Society Islands with many goods, such as pearls, pearl shell, and plaitware mats through the prehistoric period (Oliver, 1974: 214). The inter-archipelago interactions between the Tuamotus and the other island groups in Central East Polynesia may be indicative of the interaction throughout the region as a whole.

The history of Central East Polynesia is Polynesia's history. As far as the archaeological record has shown, the eastward expansion of the Austronesian peoples halted for approximately 2,000 years upon reaching Tonga and Samoa, before exploding into CEP at approximately 750-1000 BP (Wilsmhurst et al., 2011: 1817, Reith and Cochrane, 2015: 14-17). Though the timing and placement of the first colonization event within East Polynesia continues to be debated, it is generally accepted that CEP was the first region settled as Polynesian peoples moved into the Eastern Pacific (Wilsmhurst et al., 2011: 1816). According to this model, it is likely that the Polynesians then moved outward from Central East Polynesia to colonize the remaining archipelagoes within Polynesia, including the outlying Hawai'i, Aotearoa, and Rapa Nui.

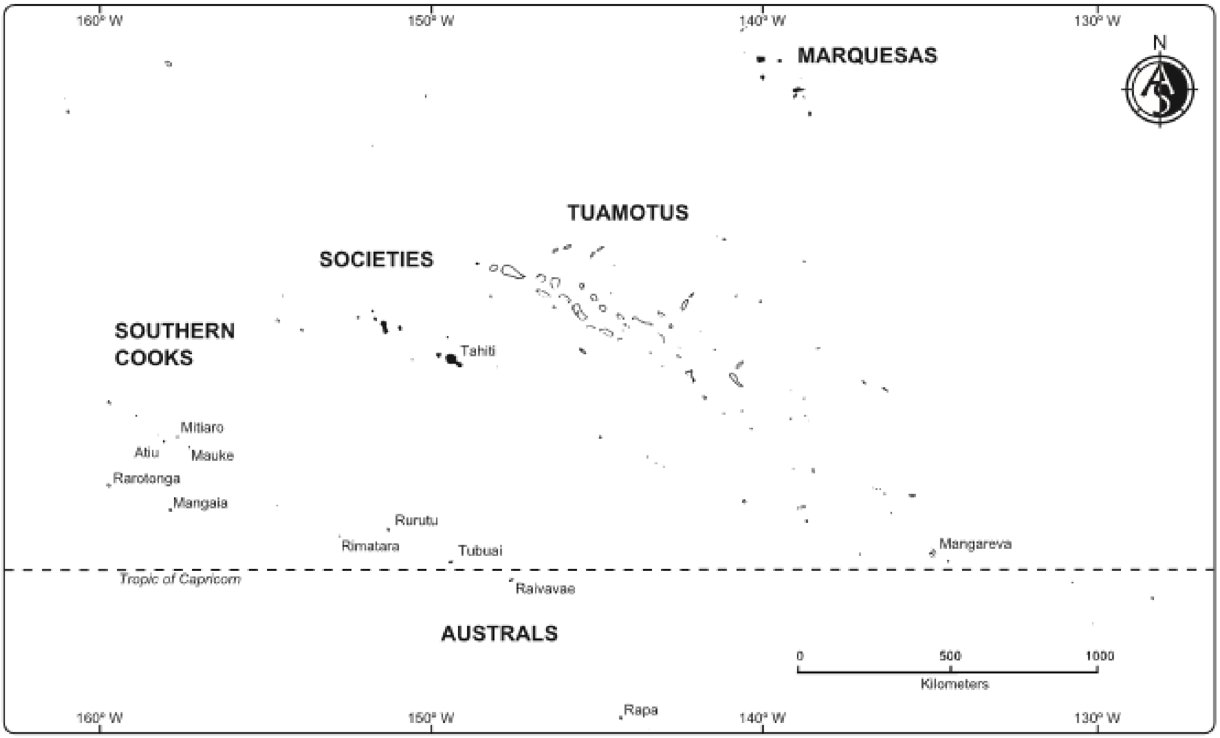

Figure 1. Map of Central East Polynesia from Rolett et al., 2015 (460). Note the position of the Tuamotus archipelago between the Society and Marquesan Island groups.

Though the initial colonization event remains debated in archaeological scholarship, post-settlement interactions within the region have been well recorded within archaeological scholarship (Allen, 2014, Collerson and Weisler, 2007, Kahn et al., 2012, Rolett, 2002, Rolett et al., 2015, Weisler, 1998). Various interaction spheres based on the exchange of goods and communication existed both within CEP and through the region. While it is likely that a wide variety of goods were traded within these interaction spheres, common goods recovered in archaeological investigation included high-quality basalts and pearl shell implements (Rolett, 2002: 182-183).

Archaeological investigations in the Marquesas have suggested a decline in interactions towards the mid-15th and early 16th centuries (Rolett, 2002: 182-183). This decline is evidenced within the archaeological record by the relative percentage of imported artifacts recovered from well-dated contexts. While it is believed that the collapse of these interaction spheres occurred at different times throughout the region, the fall-off in interactions was likely complete by approximately 1450 CE (Rolett, 2002: 185) Throughout CEP, it has been suggested that a variety of environmental and social pressures led to the ultimate decline of the majority of CEP interaction spheres (Rolett, 2002, Weisler, 2002).

The one exception to the decline in voyaging throughout CEP seems to have been the Tuamotu atolls. Ethnohistorical evidence from the Society and Tuamotus Island groups suggest that inter-island voyaging was maintained between the Society Islands and the westernmost Tuamotu atolls through the pre- and proto-historic periods (Oliver, 1974: 212-213). This interaction took several forms, including the trade of pearl shell (Oliver, 1974:214) and plaitware mats (Oliver, 1974: 151) from the Tuamotus to Tahiti. Other reports suggest contact, albeit more hostile, between the norther Tuamotus atolls and the Marquesas (Finney, 1994: 288). Further, the Tuamotuans were lauded as master shipbuilders and navigators in the Society Islands, and it is suggested that they were sought out for their expertise (Finney, 1994: 294-295). Accounts such as these suggest that the maintenance of long-distance voyaging within atoll-dwelling societies may have been an intentional, functional response to the scarcity of certain resources available on low coral atolls (Finney, 1994: 294-295, 302). If the continued contact between the Tuamotu and the Society Islands was at least in part motivated by the acquisition of resources, this should be evidenced within the archaeological record.

Archaeological investigation of the Tuamotus has been limited in recent decades. Bypassed by Bayard Dominick Expedition in the early 20th century, the first archaeological survey of the islands came in the form of the Bishop Museum 1929-1930 survey headed by Kenneth Emory. A subsequent expedition organized by the Bishop Museum continued the survey of the islands in 1934, again with Emory in charge of the ethnological and archaeological investigations (Emory, 1975: v-vi). While some other members of the expeditions published works (Gessler, 1937, Buck, 1938) concerning the Tuamotu survey shortly after the expedition, Emory's 1975 monograph *Material Culture in the Tuamotu Archipelago* remains the cornerstone archeological and ethnological report of the Tuamotuan material culture.

Over the course of the expedition, Emory collected various cultural materials for the Bishop Museum. Among these was a large collection of adzes, both of basalt and shell, which he gave for curation to the Bishop Museum. Over the years, this collection was added to through the acquisition of outside collections. All told, at the time of writing, the Tuamotus collection of adzes housed within the Bishop Museum Ethnology department totals 276 items classified as adzes or adze blanks. Of these, 84 are stone and 192 are shell. These adzes provided the unit of study for this project.

This project examines the role of trade as an adaptation to resource scarcity in the Tuamotu Islands. Based on a study of functional variation in stone and shell adzes from the Tuamotus adze collection, I suggest that the Paumotu, or the inhabitants of the Tuamotus, maintained trade with the high volcanic islands of Central East Polynesia in part to acquire resources that did not naturally occur within the Tuamotus. This paper follows the analytical methods suggested by Turner (2000, 2005) and Shipton et al. (2016), emphasizing the importance of material type and intended function as the driving forces in the production of the East Polynesian adze kit. By focusing on the function of the adzes, as opposed to stylistic variation, I conclude that the acquisition of high-quality basalt from the nearby high volcanic islands in Central East Polynesia was critical to the ship-building industry present in the Tuamotus.

2. Historical Background

The historical period in Central East Polynesia truly began with the arrival of Samuel Wallis to Tahiti in 1767, followed in 1769 by Captain Cook's famous voyage. While there were some prior accounts from Spanish explorers, the shift from the prehistoric to the historic period seems to have begun in the region, as with the rest of Polynesia, after the arrival of Captain Cook. Following these early contacts, European records and exploration of the region became increasingly frequent. Early records and recorded oral histories of Tahitian and Tuamotuan society give modern scholars a somewhat limited yet useful glance into Central East Polynesian society at the transition from the prehistoric to historic period.

One of the seminal ethnohistorical works to have been published on prehistoric Central East Polynesia was Oliver's *Ancient Tahitian Society* in 1974. Oliver's focus was on the prehistoric trajectory of Tahitian society in the years and centuries leading up to European contact. In order to achieve this, his work covered a vast number of topics, and included dozens of primary documents in French, Spanish, and English. Oliver's work also included several accounts of oral histories and traditions, and his interpretations thereof. Of particular importance to this study was the inclusion of information regarding trade and interactions between Tahiti and the Tuamotus.

Oliver noted several instances of trade and interaction between Tahiti and the Tuamotus both during the early historic and the prehistoric periods. Of particular note was the trade of pearl shell and plaitware from the Tuamotus to Tahiti. Oliver notes that pearl shell was likely scarce in Tahiti during the prehistoric period, and was highly desirable as a decorative and functional material, particularly during the prehistoric period (Oliver, 1974: 138). Oliver's discussion of the trade of plaitware mats and other articles largely comes from the writings of William Ellis, an

English missionary whose writings described the trade of plaitware mats from islands "eastward of Tahiti", the quality of which exceed those of the Society Islands (Ellis, 1829: 180). However, Oliver noted that Ellis's writings were unclear regarding the antiquity of this trade, and as such, it was difficult to determine if such interaction had taken place in this form during the prehistoric period (Oliver, 1974: 151).

Oliver's interpretations of Tuamotuan interaction with Tahiti are supported by further accounts of travel between the Tuamotus and Tahiti. Oliver recounts several entries from James Morrison, a boatswain's mate aboard the HMS Bounty, which indicate several routes of interaction between Tahiti and the Tuamotus. Many such interactions seem to have taken place via Me'etia, which was under the jurisdiction of Tahiti at the time of European contact (Oliver, 1974: 213). However, Oliver notes that this was only one of three general routes followed between Tahiti and the Tuamotus, the others being via Makatea or directly between the Tuamotus and Tahiti (Oliver, 1974: 214). According to Oliver, the majority of these voyages were undertaken by the inhabitants of the Tuamotus, deliberately, for trade and political reasons (Oliver, 1974: 214).

Oliver's account of the interaction between Tahiti and the Tuamotus is corroborated by other accounts. Haddon and Hornell's *Canoes of Oceania*, published in 1936, compiles and interprets ethnohistorical, archaeological, and oral historical information regarding the construction and use of watercraft throughout Oceania. Haddon and Hornell comment on the vastly superior construction of the Tuamotuan canoes over their counterparts in Tahiti, noting the advanced style and construction of their sails (Haddon and Hornell, 1936: 51-52).

Haddon and Hornell's assertion of the superiority of the Tuamotuan canoes in prehistory seem to be supported by the employment of the Tuamotuans as master shipwrights by the

Tahitians. The authors refer to several historical sources, including Jacques-Antoine Moerenhout's 1837 work *Voyages aux iles du Grand Ocean*, published in French. Moerenhout noted, and Haddon and Hornell translated, that in order to construct the high-quality Tuamotuan style canoes, the Tahitians needed to employ the Tuamotuans (Haddon and Hornell, 1936: 80). The supply of good timber in the high Society Islands combined with the skill of the Tuamotuan shipwrights to create excellent watercraft. The authors also noted that the general design of the Tuamotuan canoes remained largely consistent throughout the archipelago, suggesting consistent and continued contact between the atolls (Haddon and Hornell, 1936: 91).

The contact between the Tuamotus and other islands in Central East Polynesia was not limited to the Society Islands, however. Finney's 1994 work *Voyages of Rediscovery* refers to the account of Pedro Fernandez de Quiros, a 16th century Spanish explorer whose journey took him through the Marquesas. According to this account, the local Marquesans recounted a tale of raiding a far southern island group, which Finney interprets as the northern Tuamotus atolls (Finney, 1994: 288). Indeed, Finney compares the maintenance of the interactions and two-way voyaging within the Tuamotus to a similar phenomenon within Micronesia, where the inhabitants of low coral atolls preserved the knowledge and skills related to long distance traditional voyaging (Finney, 1994: 294-295).

One of the keystone studies to show this continued reliance upon interisland seafaring among atoll populations in Micronesia was William Alkire's classic work, *Lamotreck Atoll*. Alkire's (1965) ethnography of the cultures of Lamotreck and the surrounding Western Caroline Islands brought to light the importance of interisland trade and social ties to the survival of atoll populations. Inherently fragile and often subject to violent storms and shifts in their environment, the people of these islands developed and maintained long distance ties to surrounding islands and populations in part to secure valuable resources that are scarce or unavailable on the individual islands (Alkire, 1965: 145-146). Such relationships relied heavily upon the knowledge and expertise of certain members of the community to construct or navigate canoes to carry the various goods between islands.

Alkire (1965) was quick to note that the interactions between the Western Caroline Islands were not restricted to economic systems of exchange. These connections were present in nearly every level of Lamotreckan society, and included political, social, and economic relationships (Alkire, 1965: 171-174). The communities of the Western Caroline Islands secured their long distance relationships through interisland marriages, familial ties, political alliances, and the exchange of gifts. In such a context, the consideration of interisland voyaging takes on a greater level of cultural significance. For those involved in the creation and maintenance of these interisland relationships, these interactions form a community across geographic or interisland lines.

3. Adzes in the Pacific

For a culture as dependent upon seafaring as the Polynesians, it will be expected that the ability to create, maintain, and repair seagoing vessels is a critical skill within the society. While this skill may be difficult to directly observe within the archaeological record, the proliferation of woodworking tools within archaeological deposits gives silent testimony to the importance of the shipbuilder within ancestral Polynesian society. The importance of these tools to the understanding of ancient Polynesia was not lost upon early archaeologists in the Pacific. The forms, functions, and production of these tools throughout the Pacific have been topics of considerable debate for several decades.

3.1 Classification

Archaeological classification systems have generally relied upon one of two foci, function and style. As Dunnel (1978) noted, the difference between these foci of classification is both fundamental and critical to the study of artifacts. Under his definition, stylistic classification systems rely upon characteristics of the artifact that do not have any “selective values” when considered from an evolutionary standpoint (Dunnel, 1978: 199). In contrast, functional classification systems rely upon the study of artifacts with regard to characteristics which, from an evolutionary point of view, “directly affect the Darwinian fitness of the populations in which they occur” (Dunnel, 1978: 199). The classification systems that have been applied to Polynesian adzes are no exception to this, as most of these systems have either sought to classify the adzes with regard to regional styles or inferred function.

The earliest studies of Pacific adzes were primarily concerned with the creation of typologies to document the observed stylistic variation. While the most commonly used typology remains Duff’s 1959 “Neolithic adzes of Eastern Polynesia”, Duff’s system was heavily influenced by H.D. Skinner’s previous works. Skinner’s contribution to the classification largely came in the form of his 1943 publication, “The classification of greywacke and nephrite adzes from Murihiku, New Zealand”, in the *Journal of the Polynesian Society*. This article presented Skinner’s typology for Pacific adzes, consisting of 10 types and 7 varieties thereof (Skinner, 1943: 65). A major determinate for Skinner’s typology was, like the later Duff systems, cross-section. However, Skinner also placed heavy emphasis on the length of the cutting edge and the size and characteristics of the grip (Skinner, 1943: 65-66). In this respect, Skinner’s work echoes that of later, more functional discussions of Pacific adzes, with the integral relationship between the bevel angle and the size and shape of the cutting edge.

The next major typology to be proposed for Pacific adzes came in a series of works. From 1940 to 1959, Duff published several iterations of his typology, each with additions and modifications. Similar to Skinner's work, Duff's typology relied heavily upon the shape of the cross-section. Using this as the primary determinate for type, Duff organized his typology to include 6 main types, each with several variants. According to Duff, these variants represented observed stylistic differences throughout the Pacific (Duff, 1959: 127). In his description of the Type 1 variants, Duff mentions that some of the observed variation may be due to the differences in materials present in the different island groups (Duff, 1959: 130). However, any variation due to material is superseded by Duff's ultimate goal: to create a chronology for adze development within the Pacific (Duff, 1959: 127).

While Duff admits that the construction of an absolute chronology is all but impossible without reliable stratigraphic evidence, the purpose of his typology was to create a relative chronology based on adze typology and geographic density thereof (Duff, 1959: 141-143). This is key to understanding Duff's typology, and applying it. The groupings were not based on any functional aspect, but rather with the ultimate goal of understanding cultural change throughout the Pacific. The descriptions of regional variation found in Duff's typology has been important to archaeological research in the Pacific, and for this reason Duff's groupings have continued to be used, some 50 years after they were presented. However, the lack of function, combined with the stylistic descriptions for Duff's groupings have been important points of criticism in recent decades.

Following Skinner and Duff's typologies, Pacific archaeologists began to explore the use of metrics, both descriptive such as length, width, edge angle, etc. and various ratios of these measurements, to describe variation within Pacific adzes. One of the earliest studies that eschewed the group descriptions set forth in Duff's typologies was Garanger's "Herminettes lithiques oceaniennes" (1972). Garanger's study was outstanding due to its deep exploration of the metric characteristics of the adzes studied. Garanger examined not only the adzes, but also the metrics themselves to determine the most important measurements and ratios for describing variation (1972: 264-267). This was an important step away from the group-based descriptions given by Duff, and towards a systematic classification for Pacific adzes.

Another important addition to the morphometric-based approach to the study of Pacific adzes came in the form of Simon Best's 1977 study, "The Maori Adze: An Explanation for Change". While the main focus for Best's work was to differentiate between Archaic and Classic Maori period adzes, this work also highlighted the functional importance of the various angles present on a hafted adze (Best, 1977: 312-314). By testing three different types of adzes, each with different bevel and attack angles, Best determined that those adzes with relatively symmetrical bevel and edge angles were most useful when hafted and used like a modern axe (314-315). He also proposed that the Duff Type 1A was wholly unsuitable for axe-like uses, and could only be used as a scraping or shaving implement. This conclusion was based upon the unifacial angle of the cutting edge, and was later disputed by Turner's (2000) experimental study. The third adze tested, with a shorter bevel and lower angle of attack, was thought to have been a compromise between these extremes, and Best noted was efficient in a variety of woodworking tasks (Best, 1977: 315).

Best's work also noted the importance of material quality in adze manufacturing. Similar to the experiments carried out on the different types of adzes, Best stress tested various common material types found on New Zealand. He noted that the adzes made from a fine-grain material performed differently under similar stresses than those made from coarse-grain stone (Best, 1977: 332). This difference, he argued, could be expanded to the difference in tasks required from the adzes and the material. While early, fine-grain adzes were likely involved in the construction of watercraft, Best argued that the shift to coarse-grain material reflected a societal shift towards land-clearing and agricultural activities, necessitating a different kind of tool and material (Best, 1977: 332). This focus on the function of the tools was echoed in later works regarding the Pacific adze.

The most recent iteration of the metric-based approach to adze classification is Shipton et al.'s 2016 "A morphometric reassessment of Roger Duff's Polynesian adze typology". This paper specifically targeted Duff's group-based descriptions. Shipton et al. sought to test Duff's typology against their metric-based classification method drawn from Dunnel's *Systematics in Prehistory* (1971). To this end, the authors examined the adzes based on a series of principal components, including common measurements such as the poll, tang, and bevel angles, the volume of the adzes, as well as ratios that combined various measurements (2016: 369).

The principal component analysis was only one part of the author's study. Shipton et al. also relied heavily upon the analysis of flake scar patterning to determine the manufacturing methods used to create various types of adzes (Shipton et al., 2016: 369). By studying the patterns of flakes, including the number of faces that were flaked and the direction of the flaking process, the authors hoped to connect the process of adze creation with the end morphology of the adzes described in Duff's typology. By combining the principal component analysis with the study of flaking patterns, the authors attempted to capture the functional varieties of adzes recovered within the Wairau Bar excavation.

Shipton et al.'s results from this study were not quite as simple as might have been expected. While several Duff types did largely line up with the principal component and manufacturing method analysis, there was some variation (Shipton et al., 2016: 371-374). In particular, the authors found the definition of Duff types according to cross section somewhat troubling. Because the cross section of an adze can vary within the Duff types as well as between them, the authors found that there were several cases where adzes of the same type may be the result of differing manufacturing methods, or possibly where the same manufacturing method produced adzes of differing types. This variation, the authors argued, could largely be explained by studying the manufacturing methods as related to functional uses (2016: 373-374).

The results of Shipton et al.'s study suggested that two independent variables in manufacturing dictated the function, morphology, and final Duff type of the adzes. The first of these variables was the number of faces flaked, either unidirectionally or bidirectionally (Shipton et al., 2016: 373). In most cases, this variable directly related to the Duff type, as the number of faces flaked determines the final cross section, upon which many of the Duff types rely. The second variable revealed in Shipton et al.'s analysis to have been critical to the end morphology of the adzes were what the authors referred to as "functional elaborations", or those characteristics such as the nature of the tang, bevel, and the ratio of the adze weight to the length of the cutting edge (Shipton et al., 2016: 373). These elaborations, along with the number and nature of faces flaked, directly reflect decisions by the adze maker with regards to function. The form of the adze, thus, follows its intended function.

Other authors have more fully explored the functional differences present between Pacific adzes. One of the most definitive studies regarding this question of function was Turner's doctoral dissertation, "The Function, Design, and Distribution of New Zealand Adzes", published in 2000. Turner's study involved the analysis of a staggering 12,000 New Zealand adzes based on functional characteristics. Turner further added a functional, experimental portion to the analysis, where various adze types were tested in completing woodworking tasks, then compared in effectiveness against Duff's classification system (Turner, 2000: 105-107).

Through this analysis, Turner found that the New Zealand adzes could be broadly categorized into four functional designs, some of which overlapped with Duff's system. The first category Turner identified corresponded to Duff's Type 2 and partially for the Type 3 adzes. This category Turner defined as being useful for initially dressing the timber (Turner, 2000: 453). These adzes were generally thinner in the cross-section, and had relatively low bevels and wide blades, not unlike modern woodworking adzes, and were found to be useful in trimming and shaping the surface (Turner, 2000: 453). The second functional category identified by Turner also corresponded to a Duff type. This category, which consisted of adzes found useful for heavy splitting and chopping activities, was identified as being largely consistent with Duff's Type 1 adzes (Turner, 2000: 453-454). Turner found that while these adzes were previously thought to have been largely used for light shaving and shaping tasks (Best, 1977), they were actually best suited for heavy gouging and chopping tasks due to their large, heavy construction.

The third functional category identified by Turner encompassed both Duff's Type 4 and Type 6 adzes. The larger, heavier adzes were classified as Type 4, and those that were smaller and thus more useful in confined quarters corresponded to Duff's Type 6. These adzes were identified as chisels, or gouges, and had narrow blades and thick cross-sections, and were found to be useful for making deep, thin incisions (Turner, 2000: 454). The fourth, and final functional category identified by Turner corresponded to Duff type 5, and were specifically those adzes that were side-hafted. Turner proposed that these adzes were used for trimming activities in relatively confined areas (Turner, 2000: 454). See Table 1 below for the types proposed by Turner (2000) and the equivalent Duff types.

Table 1
Functional types of Polynesian adzes as defined by Turner (2000)

Turner's Functional Type	Equivalent Duff Type	Inferred Function
Type A	Type 2, Type 3	Dressing timber
Type B	Type 1	Heavy chopping and splitting
Type C	Type 4, Type 6	Gouging and chiseling
Type D	Type 5	Trimming in confined spaces

Importantly, Turner analysis noted that the shape of the cross-section, so integral to Duff's and other works, did not significantly influence the function of the adzes (Turner, 2000: 454). The question of tang presence or absence, also important to Duff's typology, did not appear to have a functional significance. Rather, these characteristics seemed to be more dependent upon the quality of raw material available in the region (Turner, 2000: 455). On the other hand, the bevel angle was found to be critical to the function of the adze, and largely dictated the effectiveness of the adze for performing various tasks. Likewise, Turner argued that some of the adze types identified in Duff's typology could have developed not as primary designs, but were rather adapted through the reworking process (Turner, 2000: 457-458).

Turner's 2000 dissertation served as the backdrop for a later paper, published in the New Zealand Journal of Archaeology in 2005. In this work, Turner elaborated on the findings of the previous study, and expanded upon her conclusions. While her 2000 work only reported four functional adze types, Turner's 2005 article expanded this conclusion to include two additional functional types. With the addition of these two functional types, Turner argued that the primary Duff types largely corresponded with function, validating the Duff typology and allowing for the relatively simple connection between familiar types and functionality. Variation within the types, such as 2A, B, C, etc., could be attributed to either the quality of material or the reworking process, as opposed to stylistic variations (Turner, 2005: 90-92).

The importance of functional considerations when discussing adzes has not been lost upon the archaeological community, and other authors have begun to include discussions of functionality to their work on Pacific adzes. One study, published in 2015 by Kahn and Dye, applied the question of functionality to Type 5 Hawaiian adzes. This study focused on the difference in functionality between single- and double-bevel tools (Kahn and Dye, 2015: 18-19). Based on their investigation, the authors asserted that the double-bevel tools were likely used as axes. The authors note that, outside of Hawai'i, axes are generally grouped with the Type 5 adzes, including side-hafted varieties, and are frequently missing from archaeological assemblages in Hawai'i (Kahn and Dye, 2015: 22). The authors argued that the Hawaiian axes were likely specialized for light cutting and chipping work, given their relatively low weight and thin widths (Kahn and Dye, 2015: 22-23). The specialized construction of these axes for specific tasks help to support the authors', and previous scholars', arguments for a functional, class-based system for organizing Pacific adzes.

3.2 Shell Adzes

Shell adzes have also been a subject for study in Pacific archaeology. While stone adzes have largely dominated the scholarship in terms of classification and typologies, there have been efforts to organize and interpret the use of shell as a material for adzes. One such study took place within a much larger, more comprehensive work. Kirch and Yen's *Tikopia: The Prehistory and Ecology of a Polynesian Outlier* included a review of 234 shell adzes recovered from Tikopia. While the authors primarily constructed their typology to fit the variation seen within the sample, they did not presume that their typology would be inapplicable outside of Tikopia (Kirch and Yen, 1982: 208).

The authors' criteria for classifying the adzes were robust, and heavily informed by their sample. The authors first divided the adzes in terms of size. Those adzes less than 40mm were classified separately. Second, the authors organized the adzes by material type. Kirch and Yen identified adzes of *Tridacna*, *Cypraea*, and *Conus* shell, and used these natural divisions in material as the chief points of separation in their typology (Kirch and Yen, 1982: 222). Third, as prior researchers in Micronesian archaeology had done (Rosendahl, 1969), the authors separated the adzes of *Tridacna* shell based on the region of the shell used to create the adze, whether it came from the hinge or dorsal region of the shell. Finally, the authors separated the adzes into individual types based on the cross section for those adzes from the hinge region, and the morphology of the butt for those from the dorsal region (Kirch and Yen, 1982: 222).

Another study, "Review of Tridacnid Ecology and Some Possible Implications for Archaeological Research" published in 1985 by Barbara Moir, considered the importance of research regarding shell adzes within the Pacific. While this study was primarily concerned with the distribution of different species of *Tridacna*, the author also made note of the different portions of the shell that were commonly used in tool production. As other scholars have noted, Moir stressed the importance of the difference between adzes from the dorsal and those from the hinge region of the *Tridacna* shell. The natural differences in shape between these regions likely influences the differences in morphology for the finished adzes. These differences in habitat and in the utilization of shell resources, Moir argued, might be useful for research into the exploitation of maritime and terrestrial resources throughout the Pacific.

A more recent study of shell artifacts was published in 2015. Katherine Szabo's article, "Shell Artefacts and Shell-Working within the Lapita Cultural Complex", compared shell artifacts throughout various Lapita assemblages in an attempt to synthesize the current archaeological data on the use of shell within the Lapita cultural complex. Szabo notes that in Lapita collections, the majority of shell adzes are produced from one of two areas on the *Tridacna maxima* shell. In general, the adzes made from large shells in these collections are produced from either the hinge section, or are made from the valve body (Szabo, 2015: 120).

3.3 Geochemical Sourcing

Within the last two decades, much of the archaeological understanding of CEP interaction has come from the geochemical analysis of basalt adzes recovered within the region. This understanding relies upon the use of X-ray fluorescence or XRF analysis upon the recovered adzes and on samples of basalt recovered from various island sources. While debate continues regarding the effectiveness of variations of XRF analysis, the application of such techniques has greatly enhanced the understanding of the CEP past. One of the earlier studies to include CEP as part of a geochemically-based study was Weisler's 1998 "Hard Evidence for Prehistoric Interaction in Polynesia", which included the investigation of material from the Marquesas, the Society Islands, and Mangareva (Weisler, 1998: 523-524). Based on the XRF analysis of adzes recovered from these islands groups, Weisler concluded that the adzes found throughout CEP could indeed have been transported over great distances from their source quarries to the final destinations (Weisler, 1998: 528-529). With the success of this study, Weisler noted the importance of geochemical sourcing to archaeological research, and that further understanding of the adze sources throughout Polynesia could greatly enhance the understanding of previously hypothesized interaction spheres.

These hypothesized interactions have been a major addition for many discussions of CEP prehistory for the last several decades. A recent geochemical study dealt directly with the Tuamotus adze collection that was the subject of study for this paper. Collerson and Weisler's

2007 study “Stone Adze Compositions and the Extent of Ancient Polynesian Voyaging and Trade”, aimed to examine the CEP interactions based on geochemical studies of adzes from the Tuamotus atolls. The Tuamotus have no sources of naturally-occurring basalt for tool making. Therefore, any basalt adzes found on the atolls must have originated from elsewhere. As such, the authors sought to use this region as a case study for the larger CEP interaction spheres. By using XRF analysis on 19 of the Tuamotus adzes, the authors determined that the Tuamotus were a major hub of interaction in CEP. The authors reported that the sample contained adzes from the Society, Marquesan, Austral, Pitcairn, and Hawaiian island chains (Collerson and Weisler, 2007: 1907-1909). While the temporal context of these adzes were unfortunately lost when they were collected during the early 1900s, the sourcing data has been valuable in interpreting the role of the Tuamotus within the CEP interaction spheres.

Another of the earlier works to apply geochemical analysis to this question of interaction was Rolett’s 1998 monograph, *Hanamiai: Prehistoric Colonization and Cultural Change in the Marquesas Islands*. This work detailed a long-term excavation that took place on Tahuata, within the Marquesas Islands, between 1984 and 1985, to study the cultural change that took place within the Marquesas prior to European contact (Rolett, 1998: 61-62). In addition to a plethora of faunal remains and fishing implements, this excavation also uncovered 38 basalt adzes and adze fragments from five excavation phases (Rolett, 1998: 188). Of these, 33 adzes and 4 adze flakes were analyzed using XRF techniques. Additionally, 52 flakes deemed too small for XRF analysis were analyzed using an electron-microprobe, which allowed for a similar though somewhat less accurate appraisal of the chemical composition (Rolett, 1998: 189).

Through this analysis the author determined that of the 33 adzes and 56 flakes analyzed, 41 came from a well-known quarry on Eiao, within the Marquesas Islands, approximately 130 km north of Tahuata (Rolett, 1998: 189). While the Eiao quarry was the most represented source for the excavated material, the author noted that another as yet unknown source was represented by a cluster of 12 adzes and flakes tested (Rolett, 1998: 189-190). While the exact source of these artifacts had not yet been determined, the author noted that the geochemical similarity of these adzes and flakes to one another suggested that they were retrieved from a single quarry. The remaining adzes and flakes exhibited high geochemical variability, and came from a variety of sources likely situated in the southern Marquesas (Rolett, 1998: 191). A later publication on the Hanamiai site and CEP interactions compared the evidence recovered from Tahuata to excavations in the Cook and the Society Islands within the context of the collapse of interaction spheres (Rolett, 2002: 184-185). Rolett argued that the interactions seen in the Cook and Society Islands could be used as an example for understanding the interactions linking the Marquesas and other island groups. As seen in the Cook and Society Islands, items and materials that did not occur naturally on islands within the Marquesas may have been traded from outside the archipelago for the high quality Eiao basalt (Rolett, 2002: 184).

The push to identify unknown basalt sources, such as that described in the Hanamiai excavation is an important step in understanding prehistoric CEP interactions. In order to accurately describe the extent of CEP interactions, prehistoric quarries need to be found and geochemically tested. This will allow for the connection of both source and destination for the lithic materials recovered from archaeological deposits. One study, published in 2015, sought to do this for a known quarry in the Austral Islands. Rolett et al.'s work, "Ancient East Polynesian Voyaging Spheres: New evidence from the Vitaria Adze Quarry", detailed the exploration and geochemical testing of a prehistoric adze quarry on Rurutu (Rolett et al., 2015: 459-460).

In addition to the investigation of the Vitaria quarry, the authors also tested seven adzes from the Peabody Essex Museum, which had been surface collected from Raivavae and Tubuai (Rolett et al., 2015: 463). Of these, two of the adzes are geochemically all but indistinguishable from the Vitaria source, and two other adzes likely came from other quarries on Rurutu (Rolett et al., 2015: 467). The remaining adzes were found to have likely come from elsewhere on Rurutu or within the Austral Islands (Rolett et al., 2015: 467-468). The immediate result of this investigation was the identification of a major prehistoric quarry within the Austral Islands, and to differentiate it from other known quarries on Rurutu. However, the authors noted that the ramifications of this study could be considerable. At the time of publication, the authors noted that adzes from Rurutu had been recovered from archaeological contexts throughout the Austral Islands, the Southern Cook Islands, The Society Islands, and the Tuamotu atolls (Rolett et al., 2015: 469-470, Collerson and Weisler, 2007).

While it is no surprise that societies living on islands with little or no high quality basalt tended to import the higher quality stone from elsewhere, several studies have revealed that this stone frequently traveled extreme distances between the source and the final destination. The quarries on Eiao, well established within the archaeological record as an important source for basalt within the Marquesas (Rolett, 1998), were evidently also part of interactions stretching to the Cook Islands (McAlister et al., 2013). As part of a larger study published in the Journal of the Polynesian Society, McAlister et al. identified an adze recovered from the Cook Islands Library and Museum Society as having been quarried from Eiao (McAlister et al., 2013: 261). The authors noted the importance of this discovery, as this adze was an outlier from the majority of those tested, which generally came from sources closer to the archipelago. Further, the authors noted that this was the first study that presented physical evidence for contact between the

Marquesas and the Cook Islands (McAlister et al., 2013: 267). Though oral histories had suggested the islands were in contact prehistorically, archaeological evidence had been scarce prior to this study.

Other studies have stressed the importance of the Eiao basalt quarries within the CEP interaction spheres. Allen's 2014 work, "Marquesan Colonisation Chronologies and Postcolonisation Interaction: Implications for Hawaiian origins and the 'Marquesan Homeland' hypothesis", detailed the archaeological evidence for interaction within the context of Hawaiian colonization. The author noted that stone artifacts from Eiao have been located in no less than six island groups within CEP: Mangareva, the Austral Islands, the Cook Islands, the Tuamotu Islands, the Society Islands, and the Line Islands (Allen, 2014: 10-11). While in many cases the artifacts could have been traded "down-the-line", Allen notes that oral traditions from both the Marquesas and Cook islands suggest at least some direct contact between the island groups (Allen, 2014: 10).

Interestingly, the basalt trade did not seem to be reciprocated by trade of adzes and other basalt implements into the Marquesas. Though Allen notes several large collections of basalt artifacts that have been recorded within the Marquesas, these adzes all appear to have originated from quarries within the Marquesas (Allen, 2014: 11). Instead, Allen hypothesized that the reciprocation of these stone exports came in the form of luxury items, such as red feathers, ceramics, whale teeth, and textiles (Allen, 2014: 11). This observation recalls the possibility of expanding research into CEP interaction spheres in the form of non-lithic artifacts, in line with the suggestions made in other studies (e.g. Rolett, 2002).

Continued research into the use of geochemical sourcing applications in Pacific archaeology has revealed a number of possible basalt sources throughout CEP. In a 2012 study, Kahn et al. investigated a collection of artifacts recovered from the 'Opunohu Valley on Mo'orea using XRF. Through the XRF analysis of the 47 artifacts recovered the team concluded that 14 of the artifacts, some 30%, originated from non-local sources (Kahn et al., 2012: 1201). While the majority of artifacts analyzed were determined to come from local sources, the authors noted that the large number of non-local artifacts suggest a strong link between Mo'orea and the surrounding islands. The authors noted that this study presented the first geochemical evidence for interisland trade within the Society Island chain. The artifacts, which were recovered from well-dated contexts, established that the hypothesized inter-island trade routes had become well established by the mid-14th century, and likely declined shortly thereafter (Kahn et al., 2012: 1201). Based on this and the previously mentioned geochemical studies, Pacific archaeologists have reconstructed several routes of basalt exchange through Central East Polynesia. These have heavily influenced the interpretation of long-distance voyaging and Central East Polynesian prehistory over the last two decades.

4. Research Design

The Tuamotus volcanic stone adzes have been the subject of prior research, most notably in the geochemical study performed by Collerson and Weisler in 2007, "Stone Adze Compositions and the Extent of Ancient Polynesian Voyaging and Trade". Using XRF techniques, the authors identified adzes within the collection with geochemical signatures hailing from the Society, Marquesas, Gambier, and Hawaiian Islands (Collerson and Weisler, 2007: 1907). However, only a small portion of the stone adzes, 19 of 84, were sampled. The remaining 65 stone and 192 shell adzes within the collection had undergone no additional typological or technological work beyond that published by Emory prior to the current project.

The Tuamotus adze collection at the Bishop Museum consists of three major acquisitions, and a series of smaller, sporadic acquisition events. The majority of the adzes in the collection were procured by Kenneth Emory on the aforementioned 1929 and 1934 expeditions to the region. The third major procurement of adzes occurred in 1952, from Goodwin's personal collection. While the context of the adzes from the personal collection is less clear than those collected by Emory, the adzes collected by Emory were documented in his notes and later in his 1975 monograph regarding the expedition. These adzes are known to have been surface collected, lacking temporal or stratigraphic context. For a complete record of the adzes studied, location from which they were collected, date of acquisition, and the collector, see the appended Adze Information Table.

In addition to the lack of temporal control, there exists the possibility of sample bias within the collection itself. According to the acquisition records and notes kept by Emory and others 115 of the adzes, or 43% of the collection, were recovered from one island, Napuka. On the other hand, some islands are represented by a single sample. Figure 2 shows the number and type of adzes within the Tuamotus Adze Collection gathered from each island. It is possible that patterns observed in this sample may not carry through the region at large. However, this sample is large enough to indicate functional differences between the adzes. Such differences may be used to analyze similar adze collections throughout Central East Polynesia and possibly the Pacific.

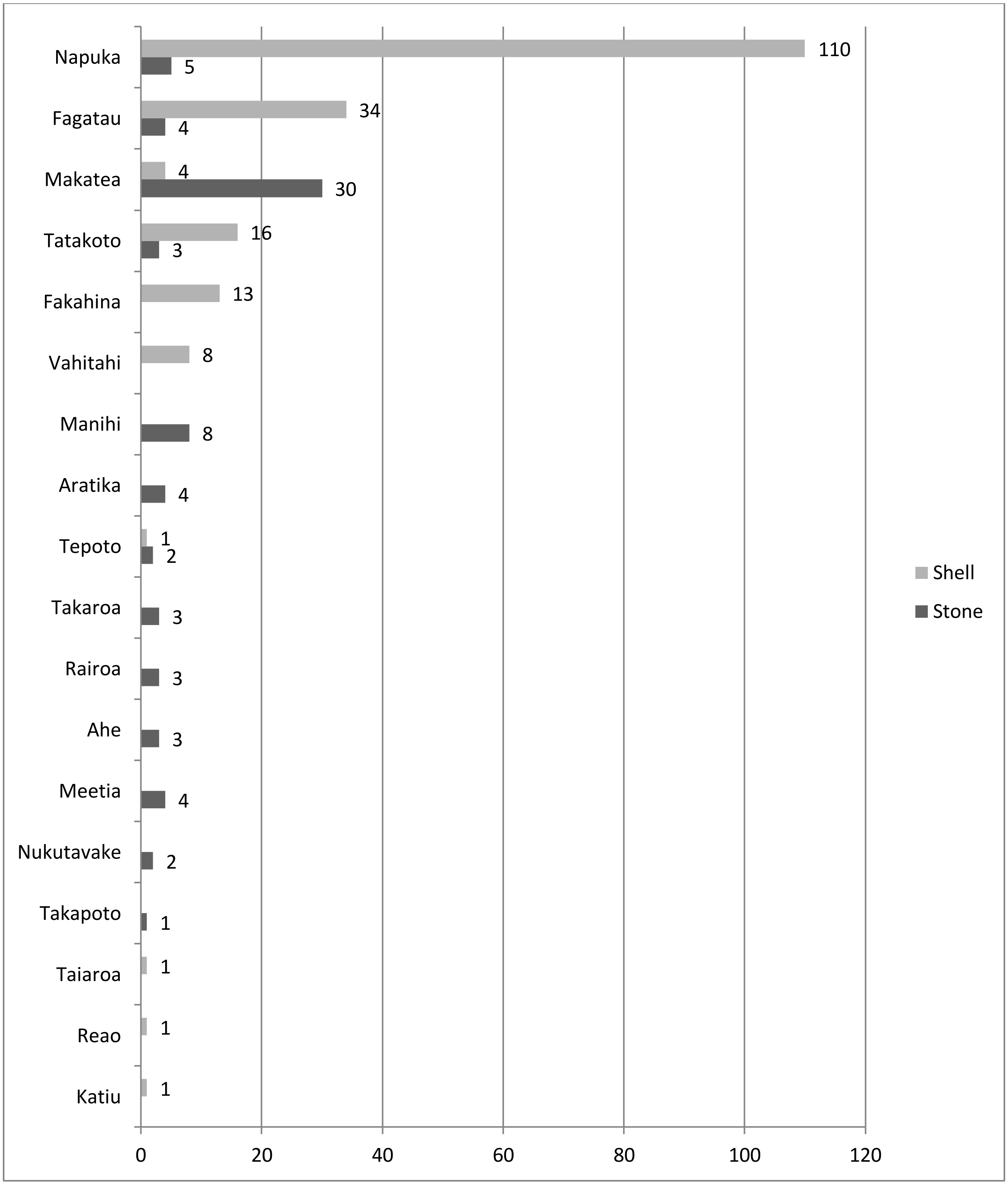

Figure 2. Number of Stone and Shell adzes present within the Tuamotus Adze Collection, complete with provenience data. Note the high number of shell adzes collected from Napuka and Fagatau, and the high number of stone adzes collected from Makatea.

The current project utilizes a two-pronged approach to the question of CEP adze manufacture and function. The first approach follows that of Shipton et al.'s "A Morphometric Reassessment of Roger Duff's Polynesian Adze Typology", published in 2016. Following this team's research model, the Tuamotus adzes were measured for the primary characteristics, including weight, length, mid-adze width, back width, face width, poll width, left and right side widths, mid-adze thickness, tang thickness, poll thickness, edge angle, bevel angle, and tang angle. Other characteristics, including the shape of the cross section, evidence for reworking, evidence of polishing, evidence of hafting, and the Duff classification were also recorded. All measurements were first taken with a pair of electronic calipers and a digital scale, supplied by the Bishop Museum Archaeology staff. If the artifact was too large or too heavy for these implements, a ruler and an analog scale was used. A standard protractor and a straight edge were used to measure the bevel, tang, and edge angles. In the case that the bevel angle was not uniform, the angle was taken between the midpoint of the bevel and the edge.

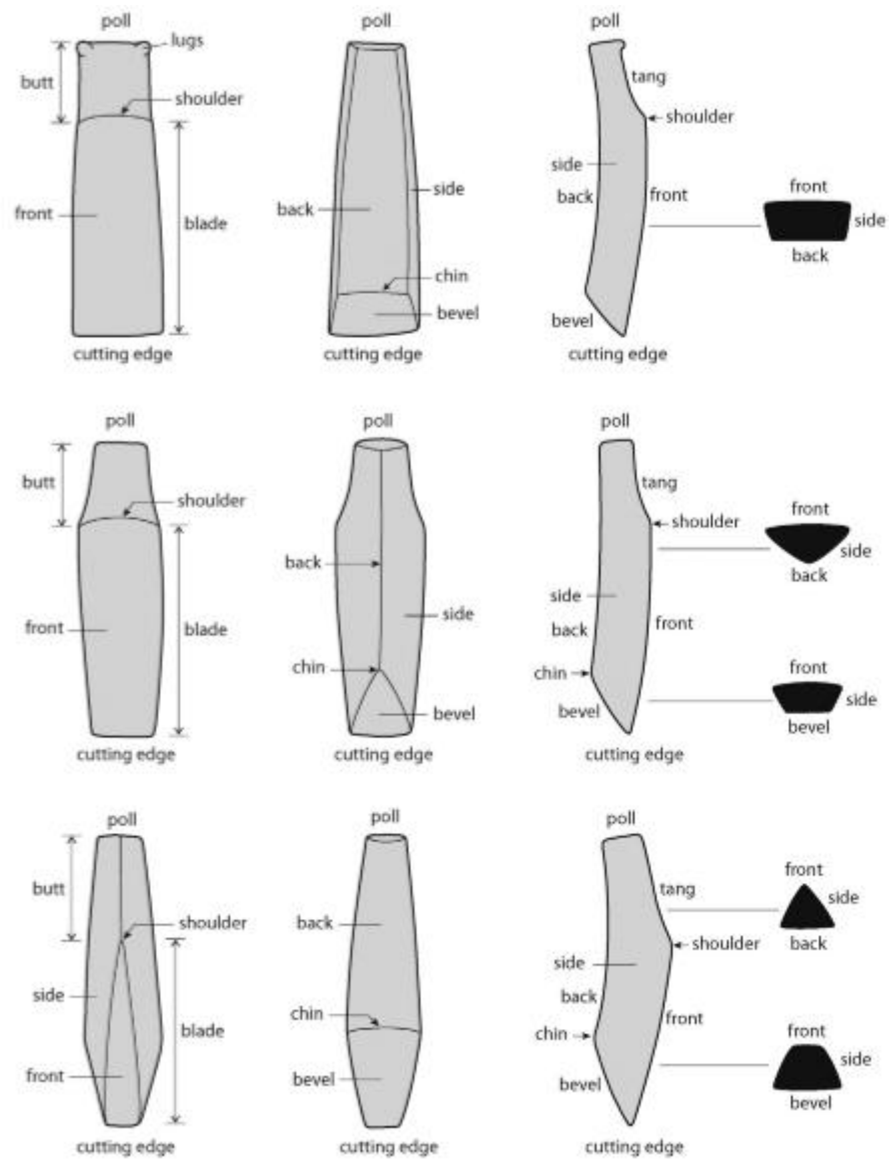

Figure 3. Standard adze nomenclature as presented in Shipton et al., 2016 (363)

Once the initial measurements had been recorded, these were used to create the ratios laid out in Shipton et al.'s study, including: back-front width ratio, side-mid thickness ratio, mid-tang thickness ratio, cutting edge width ratio, poll ratio, attack ratio, elongation, and thickness ratio (Shipton et al., 2016: 369). These ratios formed the basis for this analysis. The results were compared between the shell and stone adze. These were graphed in box-and-whiskers plots to reveal the location and spread of the stone and shell adzes in relation to one another. Those ratios which appeared to show different locations or spreads based on material type were subject to statistical tests to measure the significance of the observed differences.

The ratios used by Shipton et al. were specifically chosen by the authors to differentiate various stylistic and functional characteristics for stone adzes. The first two ratios chosen, the Back-Front Width and Side-Mid Thickness ratios were used to distinguish between adzes with various cross sections. The Back-Front Width ratio helps to identify those adzes with triangular or rectangular cross sections. The Side-Mid Thickness ratio helps identify adzes with trapezoidal, lenticular, or sub-rounded cross sections (Shipton et al., 2016: 369). However, the description of this ratio was somewhat unclear in Shipton et al.'s work. The authors describe the ratio as relying upon the widths of the left and right sides, which breaks from the standard description of adze measurements. Width, as a discreet measurement, is generally used to describe the measurement following the plane parallel to the cutting edge, while thickness is generally used to describe the measurements following the plain perpendicular to the cutting edge (Garranger, 1972: 256-258). Therefore, the thickness of the left and right sides, as opposed to the widths, was used to construct this ratio in the present study.

The next three ratios concern the expansion or contraction of the adze towards either end. The Mid-Tang Thickness ratio is used to determine if the specimen has a reduced tang, or if the adze has a constant thickness throughout the body. The Cutting Edge Width ratio identifies those adzes which expand or contract towards the cutting edge, compared to the body. Finally, the Poll ratio helps to differentiate between those adzes which contract towards the poll, and those that do not (Shipton et al., 2016: 369).

The final three ratios used from Shipton et al.'s work are the Attack, Elongation, and Thickness ratios. The Attack ratio combines information from two functional characteristics identified by Turner (2000), the weight of the adze and the width of the cutting edge. This ratio was used to distinguish those adzes used for heavy chopping and splitting, and those used for lighter shaving and carving. The Elongation ratio describes the adzes in terms of length and width, distinguishing between those adzes that are elongated, and those that are not. The Thickness ratio compares the thickness and the width of the adze at the midpoint, to distinguish those adzes that are thicker and those that have been thinned (Shipton et al., 2016: 369).

The second model for this paper was the investigation of functional variables in Turner's 2005 work, "Functional and Technological Explanations for the Variation among Early New Zealand Adzes". Through this study, Turner identified five variables critical to the function of the adze: length and weight, edge angle, edge curvature, blade width, and thickness relative to length and blade width (Turner, 2005: 63). While much of the terminology and many of the variables were similar between Turner and Shipton et al.'s works, there was one key difference. While Shipton et al. relied upon the bevel angle measurement to inform function, Turner emphasized the edge angle. See Figure 4 for an illustration of this measurement (Turner, 2005: 63, Shipton et al., 2016: 363). This study will rely upon the edge angle, in line with Turner's work. This decision was made due to the differences in focus between Turner (2000) and Shipton (2016). Turner's work was primarily focused upon the physical functional attributes of the adze, while Shipton et al. (2016) sought to use the inferred function and method of production for the adze to inform stylistic variability throughout East Polynesia. Because this study is primarily concerned with the differences in function between those adzes produced within the Tuamotus and those exchanged from outside the archipelago, I chose to rely upon the edge angle measurement to inform the function of the adzes. See Table 2 for a complete list of attributes studied.

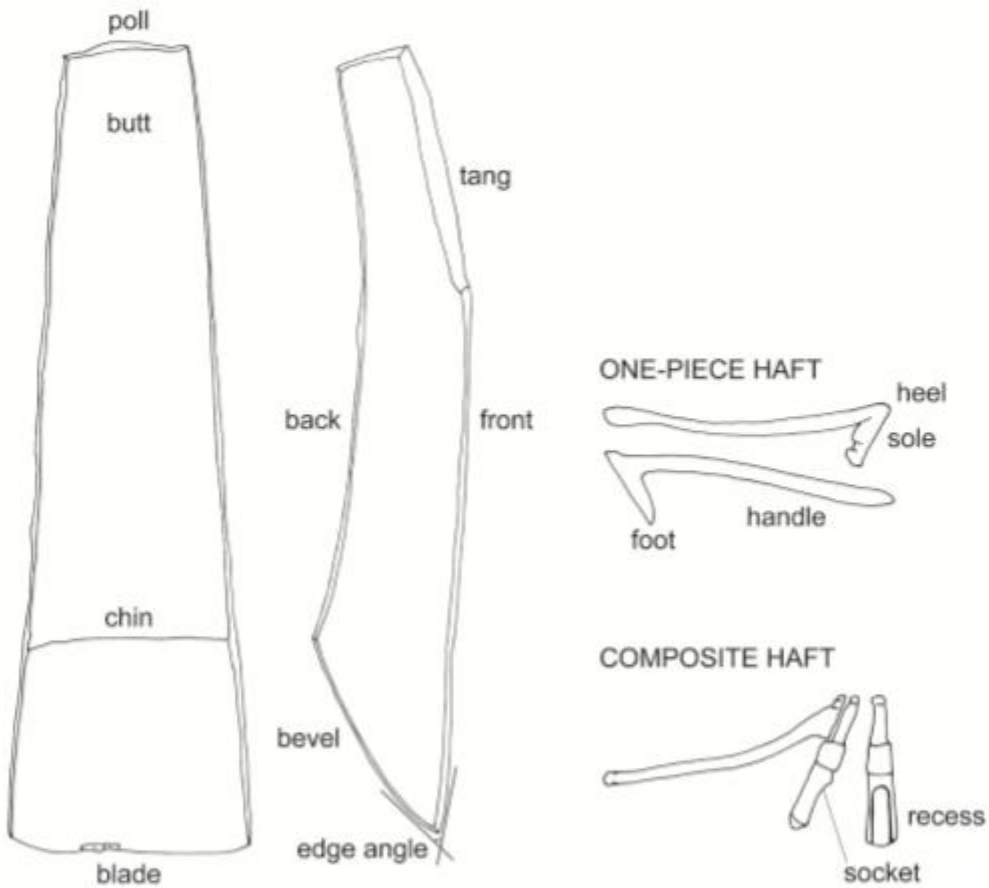

Figure 4: Adze nomenclature as presented in Turner (2005: 64). Note that Turner's illustration includes a bifacial measurement of the edge angle for the adze. This measurement was key to many of Turner's functional types.

Table 2
Ratios and attributes utilized

Functional Attribute or Ratio	Measurements Needed	Rationale	Source
Back-Front Width ratio	Front width divided by back width	Differentiate between triangular and rectangular cross sections	Shipton et al.
Side-Mid Thickness ratio	Left and Right Side Thickness*, averaged and divided by thickness at the midpoint	Differentiate between trapezoidal, lenticular, and sub-rounded cross sections	Shipton et al.
Mid-Tang Thickness ratio	Thickness at the midpoint divided by thickness of the tang	Differentiate between adzes with a reduced tang and without	Shipton et al.
Cutting edge Width ratio	Width of the cutting edge divided by width at the midpoint	Differentiate between adzes which expand or contract at the cutting edge	Shipton et al., Turner
Poll ratio	Thickness at the midpoint divided by thickness at the poll	Differentiate between adzes which contract towards the poll and those that do not	Shipton et al.
Attack ratio	Weight of the adze divided by the cutting edge width	Differentiate between adzes for chopping or shaving	Shipton et al., Turner
Elongation	Length of the adzes divided by the width at the midpoint	Differentiate between elongated and non adzes	Shipton et al.
Thickness ratio	Thickness at the midpoint divided by width at the midpoint	Distinguish between thick and thin adzes	Shipton et al., Turner
Edge Angle	Angle of the cutting edge	Differentiate between adzes used for axe-like and adze-like purposes	Turner

***Shipton et al. (2016) described this ratio as relying upon the Left and Right Side widths. However, the use of 'width' is generally restricted to the measurement of the adze along the x-axis, parallel to the line of the cutting edge. As such, this was changed to thickness, which is more universally used to describe the z-axis measurement.

5. Results

The results of the laboratory analysis are recorded below. Some ratios showed significant differences between the construction and assumed function of the stone and shell adzes, others less so. The results were plotted in box-and-whiskers graphs to compare the relative location and spread for both shell and stone. The box-and-whiskers plots were constructed within SPSS, based on the median and quartiles. The center line of the box-and-whiskers plot represents the median, and the bottom of the box represents the first quartile. The top of the box represents the 3rd quartile. The whiskers extend above and below the box to 1.5 times the interquartile range, or the distance between the first and third quartile. Outliers are defined as those points falling greater than 1.5 times the interquartile range outside the box. Far outliers are those points falling greater than 3 times the interquartile range outside the box. The results of the ratios were then subject to Mann-Whitney U-tests to determine statistical significance for each observed difference. Such differences, if found to be significant, could directly relate to differences in the intended function of stone and shell adzes.

5.1 Back-Front Width Ratio

Figure 5 displays the Back-Front ratio for the sample. This ratio is calculated by dividing the width of the face at the midpoint by the width of the back at the midpoint. This ratio, according to Shipton et al., was designed to differentiate between adzes with a triangular cross-section and those without (2016: 369). For this ratio, those data points at 1 represent adzes with equal back and face widths. Those data points which fall above 1 represent adzes that have a wider face than back, suggesting a more triangular shape. However, this ratio does not distinguish between those adzes which have equal widths due to a rectangular cross section and those that have ovular or lenticular cross sections. Rather, this ratio must be combined with that represented in Figure 6 to differentiate between the rectangular, triangular, ovular, and lenticular specimens.

The sample contains 192 shell and 83 stone adzes. Figure 5 displays the range, median, and interquartile ranges for the sample. The Back-Front ratio of shell adzes ranges from .51 to 3.11, with a median of 1.00. The mean Back-Front ratio for shell adzes is 1.04 ± .22 (Fig. 5). The Back-Front ratio of stone adzes ranges from .24 to 127.4, with a median of 2.02. The mean Back-Front ratio for the stone adzes is 10.63 ± 26.57. This difference in observed spread between the shell and stone adzes suggest a fundamental difference in construction. While the morphology of the stone adzes is somewhat constrained by the shape of the raw material, the morphology of the shell adzes is likely far more dependent upon the shape of the natural materials. The natural shape, curvature, and size of the *Tridacna* shell used to create these tools would likely have influenced the amount of control the artisan could exert over the morphology of the final tool. A Mann-Whitney U-test showed a significant difference between the stone and shell adzes ($p<.0001$, $u=2141$, $z=-9.62$). The full range of the Back-Front Width ratio for stone adzes (127.67) is not shown by Figure 5. Seven stone adzes were extreme outliers to the interquartile range. These adzes grouped between 82 and 127 for the Back-Front Width ratio. Such high ratios for these adzes are the result of highly triangular cross section and well-polished construction of the adzes.

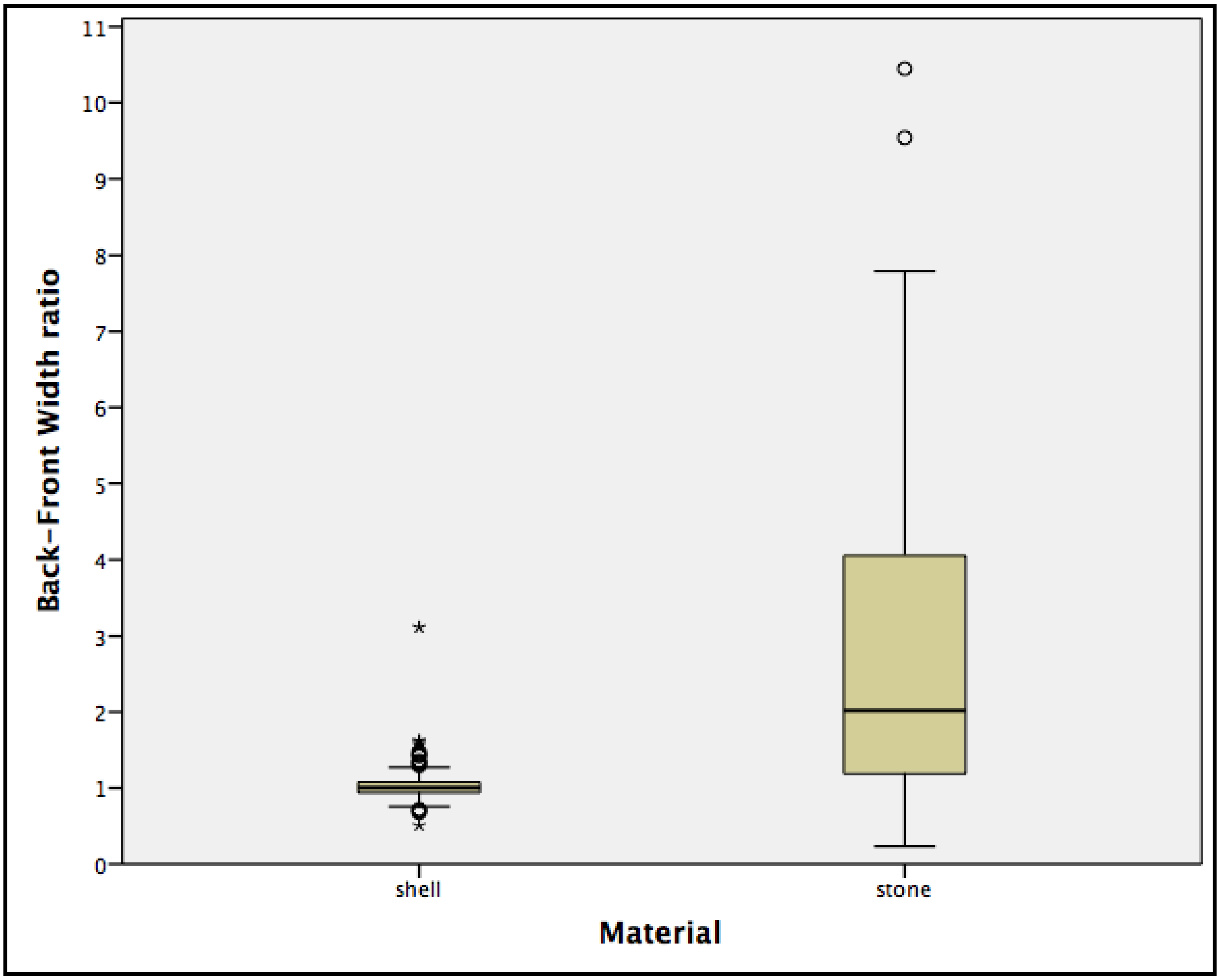

Figure 5. Back-Front Width Ratio for shell (n=192) and stone (n=83) adzes from the Bishop Museum Tuamotus adze collection. The boxplot shows the median as the center line within the box (shell=1.00, stone=2.02). The range is shown by the spread of the full sample, though several stone outliers extend past the range displayed by the figure (shell=2.61, stone=127.67). Circles above the shell adze box plot show near outliers (1.5x the interquartile range); asterisks show far outliers (3x the interquartile range).

5.2 Side-Mid Thickness Ratio

Figure 6 shows the Side-Mid Thickness Ratio for the shell and stone adzes. This ratio is calculated by dividing the average of the thickness of the sides by the thickness of the adze at the midpoint. The terminology of this ratio is somewhat unclear in the description given by Shipton et al., as the authors note is as being the average of the widths of the sides divided by the thickness of the adze (2016: 369). This somewhat conflicts with the standard nomenclature for

Pacific adzes, as the sides should be measured in terms of thickness, and thus do not have width. Nonetheless, this ratio is designed to differentiate between lenticular, sub-trapezoidal, and sub-rounded cross-sections (Shipton et al., 2016: 369). Those points falling above 1 represent adzes with sides that are thicker at the midpoint than the adze is thick, which suggest a sloping, more trapezoidal cross-section. Those points below 1 on this graph represent adzes with thinner sides at the midpoint than the adze is thick, suggesting a more lenticular shape.

The sample contains 192 shell and 83 stone adzes. Figure 6 displays the range, median, and interquartile ranges for the sample. The Side-Mid Thickness ratio of shell adzes ranges from .22 to 1.22, with a median of .79. The mean Side-Mid Thickness ratio for shell adzes is .76 ± .15 (Fig. 6). The Side-Mid Thickness ratio of stone adzes ranges from .61 to 1.74, with a median of .97. The mean Side-Mid Thickness ratio for the stone adzes is 1.00 ± .18. A Mann-Whitney U-test showed a significant difference between the stone and shell adzes ($p<.0001$, $u=1766.5$, $z=-10.24$). The difference in ratios suggests a difference in shape between the stone and shell adzes. Similar to the differences observed in the Back-Front Width ratio, this difference is likely related to the raw materials. Once again, the natural shape and curve of the *Tridacna* shell used to create these tools would likely have influenced the artisan towards creating an adze with a more lenticular shape.

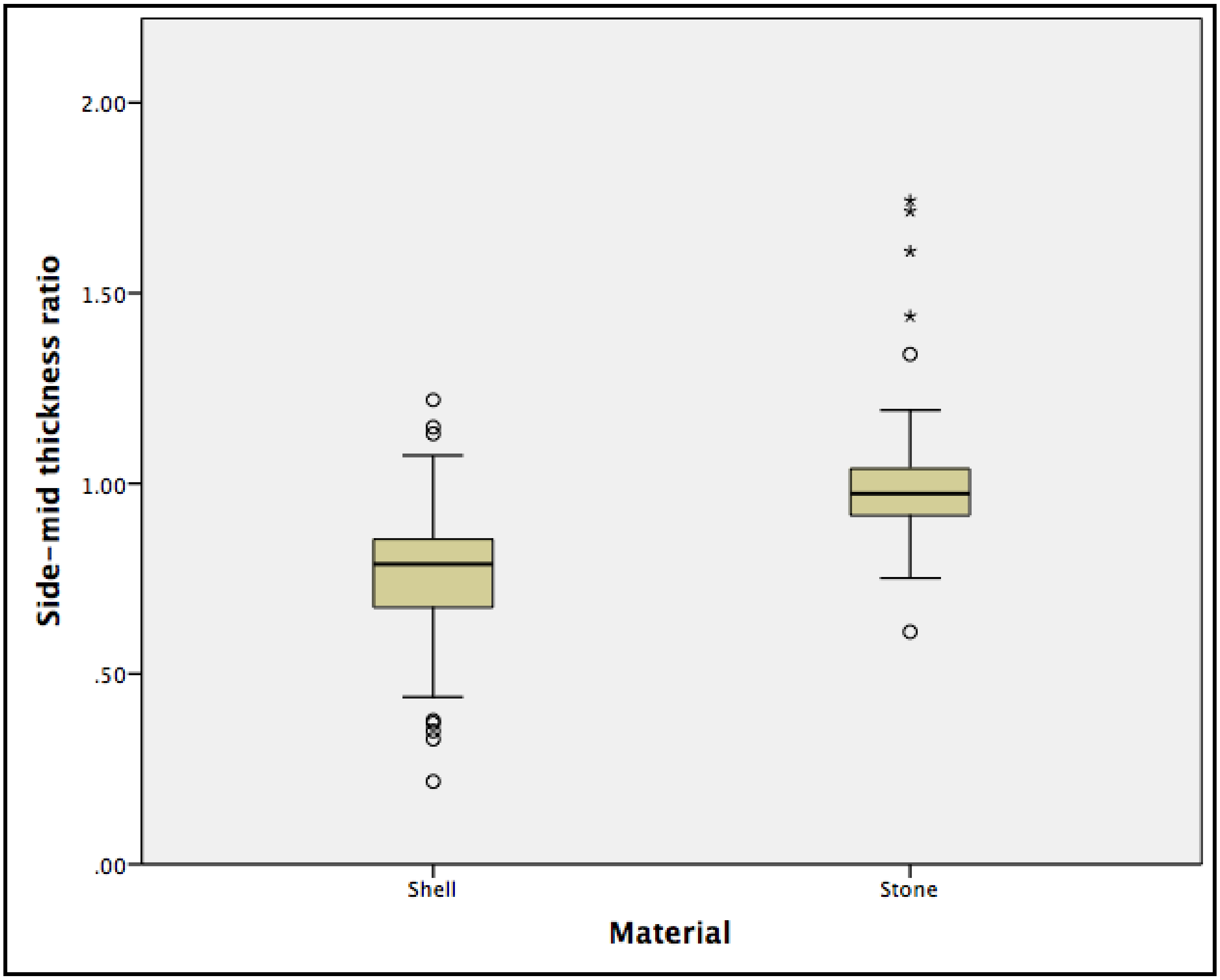

Figure 6. Side-Mid Thickness Ratio for shell (n=192) and stone (n=83) adzes from the Bishop Museum Tuamotus adze collection. The boxplot shows the median as the center line within the box (shell=.76, stone=.97). The range is shown by the spread of the full sample (shell=1.00, stone=1.13). Circles above the shell adze box plot show near outliers (1.5x the interquartile range); asterisks show far outliers (3x the interquartile range).

5.3 Mid-Tang Thickness Ratio

Figure 7 shows the Mid-Tang Thickness Ratio for shell and stone adzes. This ratio is calculated by dividing the thickness of the adze at the midpoint by the thickness of the tang. According to Shipton et al., this ratio is designed to determine the difference between those adzes with a reduced tang and those without (2016: 369). As such, those adzes with reduced tangs will fall above 1 on this graph. Those adzes with tangs as thick or thicker than the midpoint of the adze will fall below. Adzes without tangs were excluded from this analysis.

The sample contains 173 shell and 80 stone adzes. Figure 7 displays the range, median, and interquartile ranges for the sample. The Mid-Tang Thickness ratio of shell adzes ranges from .29 to 1.77, with a median of 1.06. The mean Mid-Tang Thickness ratio for shell adzes is 1.05 ± .25 (Fig. 7). The Mid-Tang Thickness ratio of stone adzes ranges from .62 to 1.86, with a median of 1.21. The mean Mid-Tang Thickness ratio for the stone adzes is 1.22 ± .23. A Mann-Whitney U-test showed a significant difference between the stone and shell adzes ($p<.0001$, $u=4164.5$, $z=-5.09$).

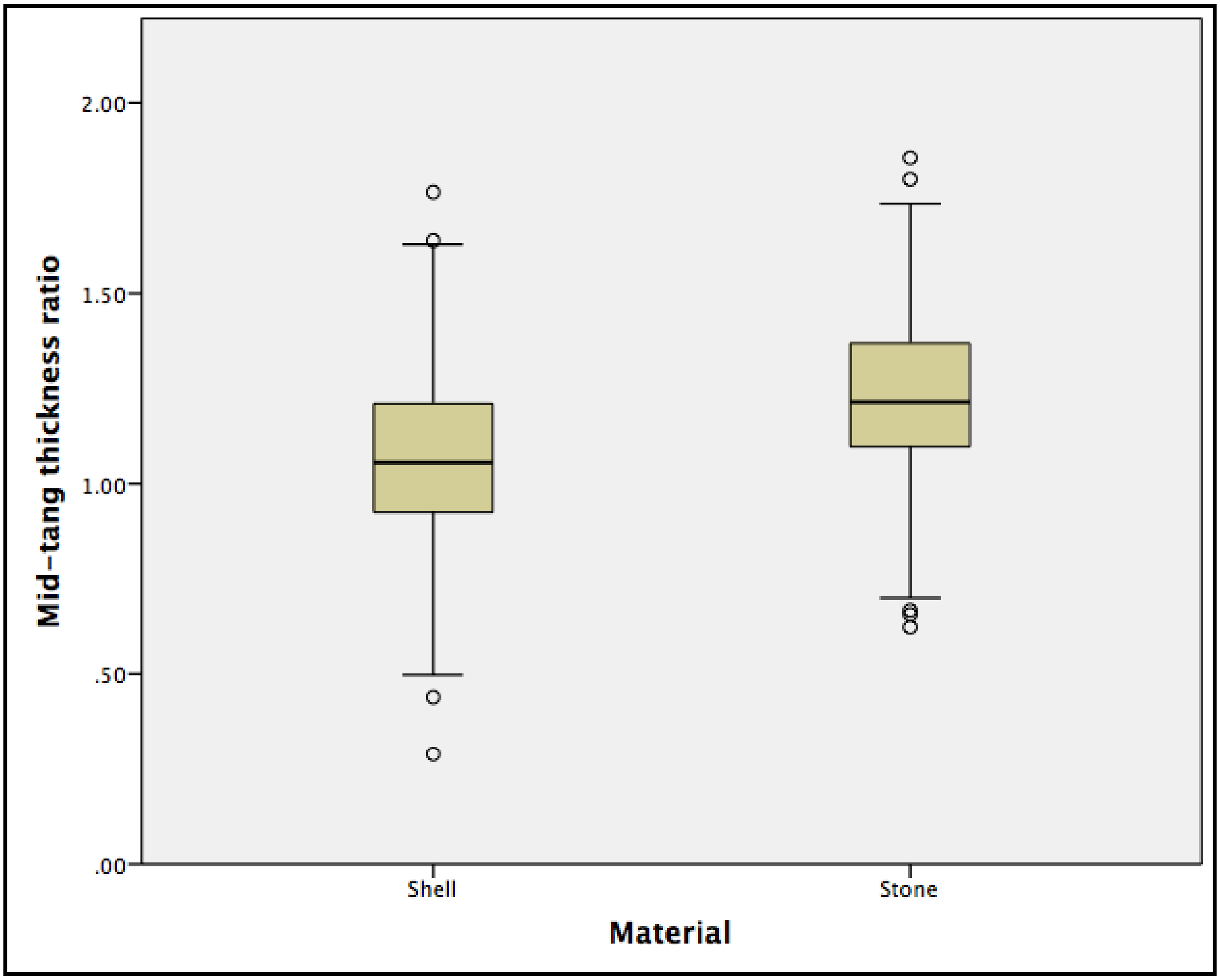

Figure 7. Mid-Tang Thickness Ratio for shell (n=173) and stone (n=80) adzes from the Bishop Museum Tuamotus adze collection. The boxplot shows the median as the center line within the box (shell=1.06, stone=1.21). The range is shown by the spread of the full sample (shell=1.48, stone=1.23). Circles above the shell adze box plot show near outliers (1.5x the interquartile range); asterisks show far outliers (3x the interquartile range).

5.4 Cutting Edge Width Ratio

Figure 8 displays the ratio between the width of the cutting edge and the width of the adze at the midpoint. This ratio is calculated by dividing the width of the cutting edge by the width of the adze at the midpoint. According to Shipton et al., this was to differentiate between those adzes which broadened at the edge and those that constricted (2016: 369). Those points above 1 represent adzes which have cutting edges wider than the midpoint, and those below 1 represent those adzes with cutting edges narrower than the midpoint. Those adzes without edges or with broken edges were excluded from this analysis.

The sample contains 190 shell and 78 stone adzes. Figure 8 displays the range, median, and interquartile ranges for the sample. The Cutting Edge Width ratio of shell adzes ranges from .49 to 1.58, with a median of .95. The mean Cutting Edge Width ratio for shell adzes is .96 ± .22 (Fig. 8). The Cutting Edge Width ratio of stone adzes ranges from .34 to 1.32, with a median of .95. The mean Cutting Edge Width ratio for the stone adzes is .93 ± .20. A Mann-Whitney U-test showed an insignificant difference between the stone and shell adzes ($p=.42$, $u=7024.5$, $z=.80$). Because the cutting edge width is a functionally significant characteristic of the adze, we can interpret observed differences between cutting edge widths between shell and stone adzes as indicating functional differences (Turner, 2005: 63). However, the observed differences were not statistically significant, indicating similar functions between the stone and shell adzes in terms of the cutting edge width. This suggests a relatively consistent pattern of edge width to adze width for both the stone and shell adzes, which may indicate similarities in adze production and use.

This pattern did not hold uniformly throughout the entirety of the sample. Several shell adzes fell above the interquartile range for the sample, one such adze with a relatively higher Cutting Edge Width Ratio was specimen number c4008 (fig. 8a). This adze, retrieved by Emory

Figure 8a. Adze number c.4008 from the Tuamotus Adze Collection. Note the high degree of polishing and shaping evident on this artifact.

from Vahitahi, was one of the few shell adzes to have been polished after flaking. The other outliers and extreme outliers above the interquartile range for the shell adzes generally follow this trend. These adzes were more heavily shaped and polished than other shell adzes in the sample.

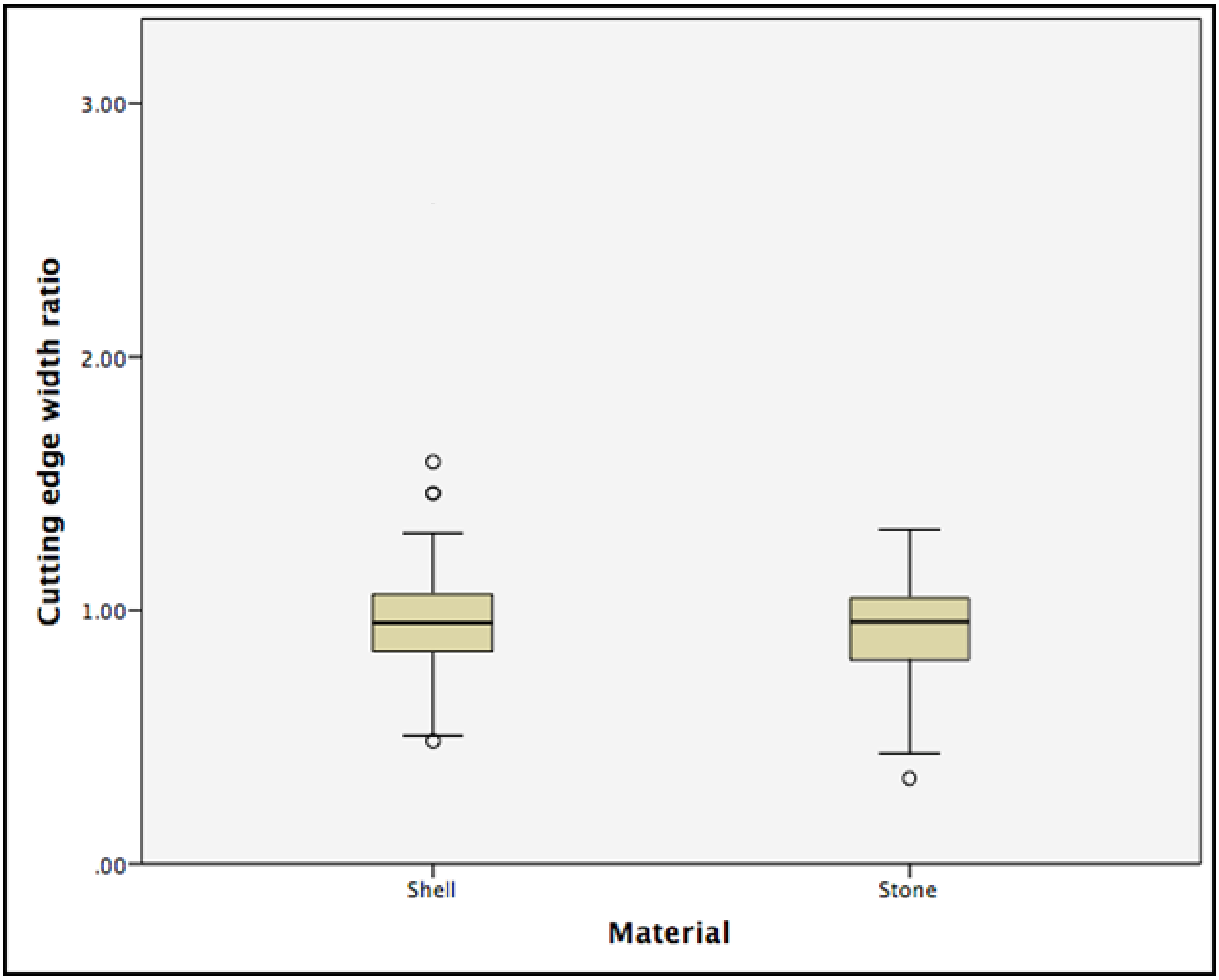

Figure 8. Cutting Edge Width Ratio for shell (n=190) and stone (n=78) adzes from the Bishop Museum Tuamotus adze collection. The boxplot shows the median as the center line within the box (shell=.95, stone=.95). The range is shown by the spread of the full sample (shell=1.10,

stone=.98). Circles above the shell adze box plot show near outliers (1.5x the interquartile range); asterisks show far outliers (3x the interquartile range).

5.5 Poll Ratio

Figure 9 displays the ratio of the thickness at the midpoint of the adze to the thickness of the poll. According to Shipton et al., this ratio is used to differentiate between adzes with heavy reduction towards the poll and those without (2016: 369). A value less than 1 indicates that the poll is thicker than the main body of the adze, showing no reduction. Those adzes with broken or missing polls were excluded from this analysis.

The sample contains 174 shell and 80 stone adzes. Figure 9 displays the range, median, and interquartile ranges for the sample. The Poll ratio of shell adzes ranges from .45 to 4.15, with a median of 1.94. The mean Poll ratio for shell adzes is 1.99 ± .55 (Fig. 9). The Poll ratio of stone adzes ranges from .95 to 3.11, with a median of 1.47. The mean Poll ratio for the stone adzes is 1.51 ± .33. A Mann-Whitney U-test showed a significant difference between the stone and shell adzes ($p<.0001$, $u=2987$, $z=7.304$). It is likely that this observed difference between stone and shell adzes is correlated to the variability in the raw material, and natural curvature of the shell. While the stone adzes can be easily flaked to reduce towards the poll, the polls for the shell adzes are generally constrained by the thickening of the *Tridacna* shell towards the hinge region.

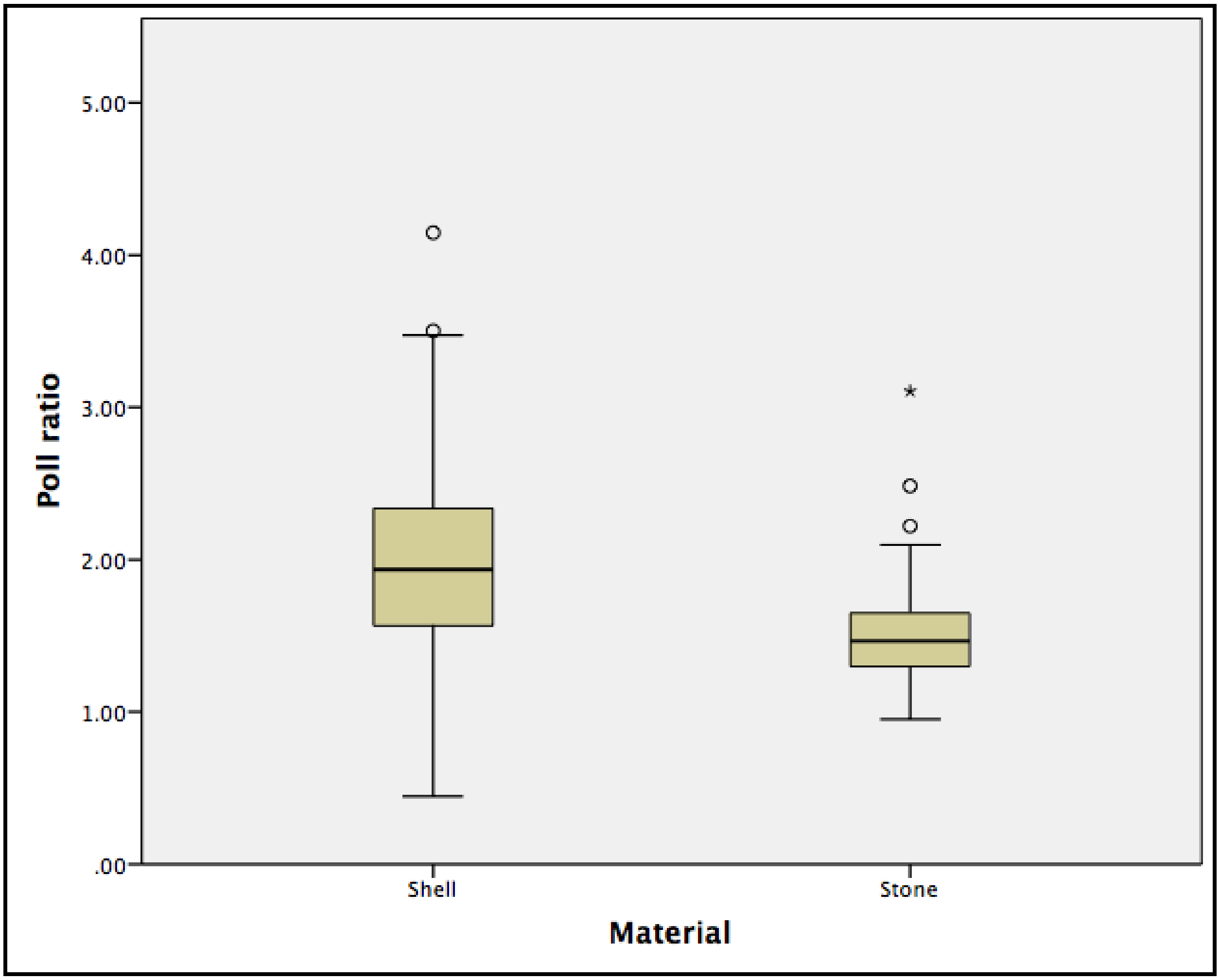

Figure 9. Poll Ratio for shell (n=174) and stone (n=80) adzes from the Bishop Museum Tuamotus adze collection. The boxplot shows the median as the center line within the box (shell=1.94, stone=1.47). The range is shown by the spread of the full sample (shell=3.70, stone=2.16). Circles above the shell adze box plot show near outliers (1.5x the interquartile range); asterisks show far outliers (3x the interquartile range).

5.6 Attack Ratio

Figure 10 displays the attack ratio for the sample. This ratio divides the weight of the adze by the width of the cutting edge, and according to Shipton et al. is used to differentiate between those adzes intended for chopping and those intended for shaving (2016: 369). While Shipton et al. do not distinguish an absolute value at which the inferred function shifts from shaving to chopping, the relative spread of the ratio for shell and stone adzes indicates this difference. Due to the significant difference in density between basalt and Tridacna shell, it is no surprise that the distributions for shell and stone adzes differ greatly. The Tridacna material is far less dense than volcanic basalt. Therefore, a Tridacna adze of the same volume as a basalt adze will weigh considerably less. This would likely factor into the artisan's decision regarding the intended function of the tool. Those adzes with broken or missing cutting edges were excluded from this analysis.

The sample contains 191 shell and 78 stone adzes. Figure 10 displays the range, median, and interquartile ranges for the sample. The attack ratio of shell adzes ranges from .47 to 10.35, with a median of 2.21. The mean attack ratio for shell adzes is 2.82 ± 1.83 (Fig. 10). The attack ratio of stone adzes ranges from 1.49 to 37.47, with a median of 10.24. The mean attack ratio for the stone adzes is 13.17 ± 9.42. Given Turner and Shipton et al.'s agreement regarding the functional importance of the weight and length of the cutting edge, the contrast between these plots strongly suggests a divide in function based on material type (Turner, 2000: 63, Shipton et al., 2016: 369). A Mann-Whitney U-test showed a significant difference between the stone and shell adzes ($p<.0001$, $u=997$, $z=-11.62$).

Both Shipton et al. (2016) and Turner (2005) agree that the width of the cutting edge relative to the length, weight, and thickness of the adze is critical to the function of the tool (Shipton et al., 2016: 369; Turner, 2005: 63). Shipton et al. and Turner agree that those adzes with larger cutting edges and lower weights are generally used for shaping and shaving tasks, as opposed to heavier gouging and chiseling tasks. This requirement for wider cutting edges and lower weights is reflected within the low attack ratio for shell adzes. The low attack ratios for these adzes reflect wide cutting edges and low adze weights. Notably, the range of the stone adzes includes the total range of the shell adzes. As such, it would seem that while the sample of stone adzes includes those with different functionality, it also includes adzes which are functionally similar to the shell adzes.

Several shell adzes exhibit Attack ratios closer to those exhibited by the majority of stone adzes (Fig. 10). One such outlier was adze number c2963 (Fig. 10a). This adze, along with the other outliers above the interquartile range for shell adzes exhibit higher total weights than the majority of shell adzes, while keeping relatively similar cutting edge widths. This gave the outliers to the shell interquartile a closer Attack Ratio to the median Attack Ratios for stone adzes. While the majority of shell adzes exhibited different Attack Ratios than those shown in the sample of stone adzes, these shell outliers may have been used in a similar fashion to many stone adzes.

Figure 10a. Adze number c2963 from the Tuamotus Adze Collection. This adze, along with several other outliers, exhibited higher adze weights and Attack Ratios, due to the limited amount of reduction in producing these adzes.

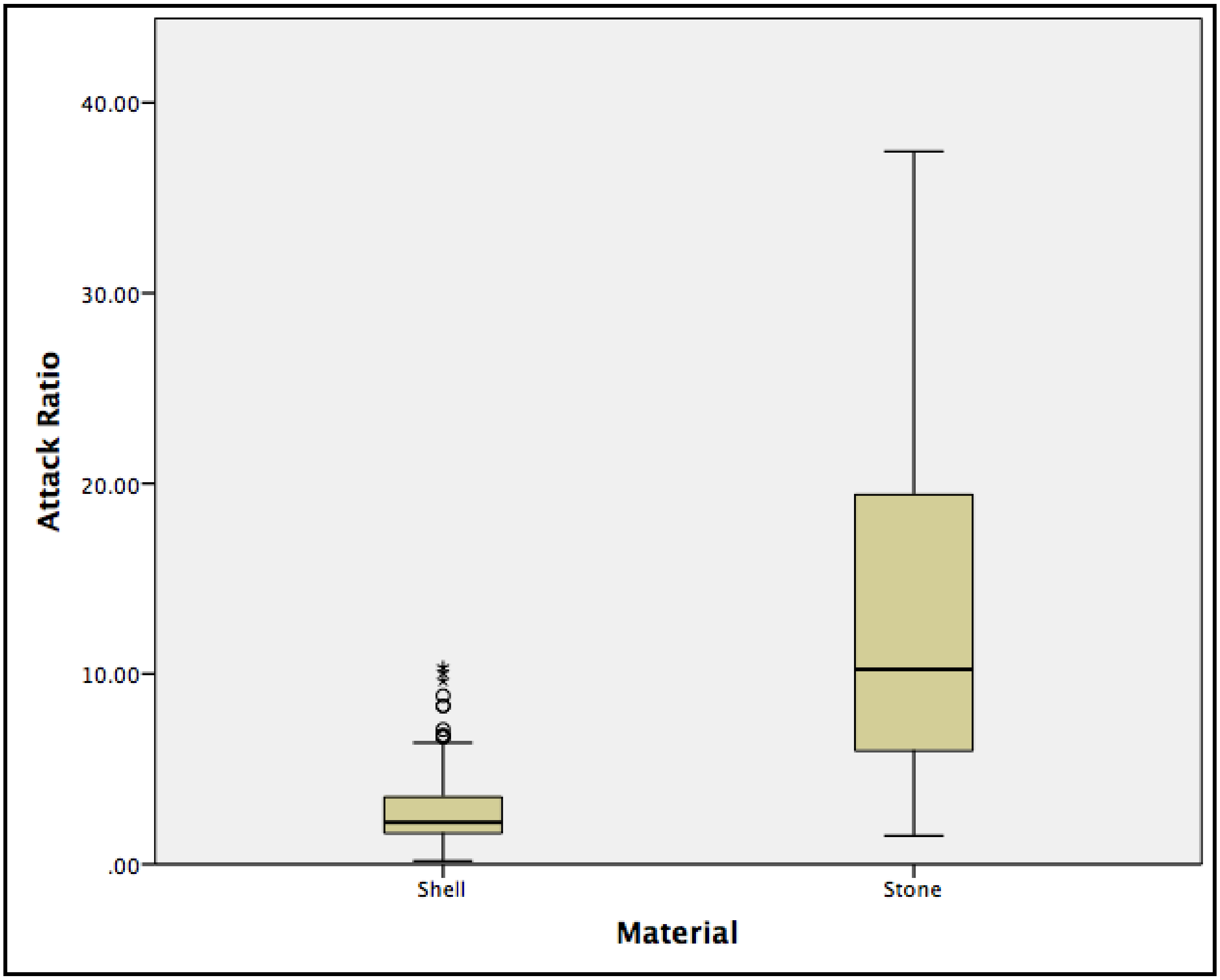

Figure 10. Attack Ratio for shell (n=191) and stone (n=78) adzes from the Bishop Museum Tuamotus adze collection. The boxplot shows the median as the center line within the box (shell=2.2, stone=10.2). The range is shown by the spread of the full sample (shell=10.2, stone=35.9). Circles above the shell adze box plot show near outliers (1.5x the interquartile range); asterisks show far outliers (3x the interquartile range).

5.7 Elongation Ratio

Figure 11 displays the Elongation ratio for the sample. This ratio divides the length of the adze by the width at the midpoint, to differentiate between those adzes that are longer and more narrow and those that are shorter and wider (Shipton et al., 2016: 369). The sample contains 192 shell and 83 stone adzes. Figure 11 displays the range, median, and interquartile ranges for the sample. The Elongation ratio of shell adzes ranges from .24 to 7.36, with a median of 2.18. The mean Elongation ratio for shell adzes is 2.42 ± .97 (Fig. 11). The Elongation ratio of stone adzes ranges from .59 to 6.98, with a median of 3.50. The mean Elongation ratio for the stone adzes is 3.59 ± 1.12. A Mann-Whitney U-test showed a significant difference between the stone and shell adzes ($p<.0001$, $u=3120$, $z=-8.01$).

Similar to the trend observed in several other graphs (Fig. 5, 6, 7, 9), the observed differences may be related to the natural restrictions of the shell as opposed to stone adzes. The final shape of the adze is likely influenced by the relative thickness of the natural material. Interestingly, Figure 11 also shows several outlying shell adzes above the interquartile range. These points correspond to a difference in shell type. The outlying points represent shells of *Cypraea*, which are chiefly constructed from the lip of the shell. This leads to a much narrower final product than those adzes constructed from the hinge or valve region of the *Tridacna* shell. In this case, the difference in material type leads the shell adzes in the sample to exhibit a larger range than the stone adzes.

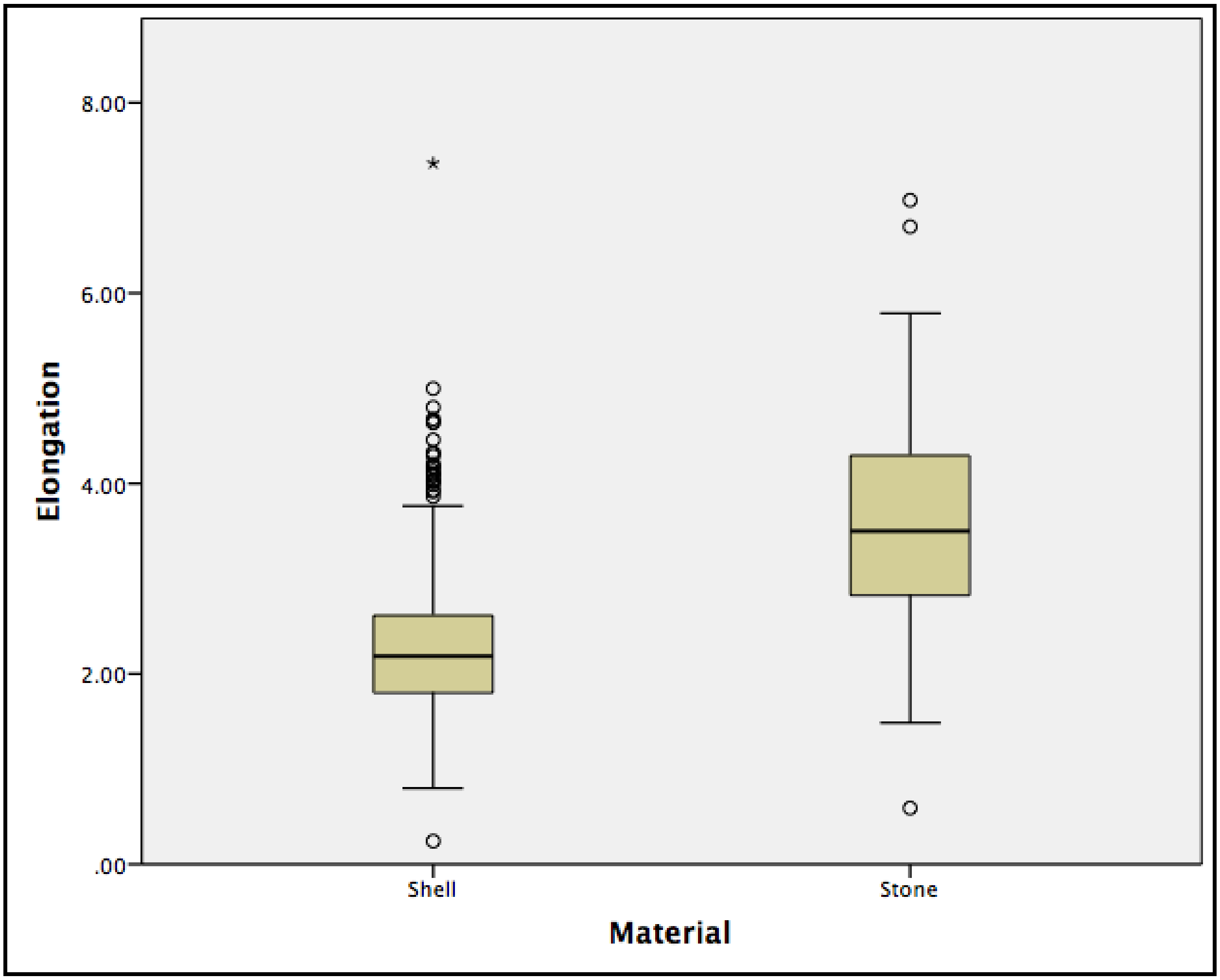

Figure 11. Elongation Ratio for shell (n=192) and stone (n=83) adzes from the Bishop Museum Tuamotus adze collection. The boxplot shows the median as the center line within the box (shell=2.18, stone=3.50). The range is shown by the spread of the full sample (shell=7.12, stone=6.39). Circles above the shell adze box plot show near outliers (1.5x the interquartile range); asterisks show far outliers (3x the interquartile range).

5.8 Thickness Ratio

Figure 12 displays the thickness ratio for the stone and shell adzes. This ratio divides the thickness of the adze at the midpoint by the width of the adze at the midpoint, and is used to differentiate between taller and broader adzes (Shipton et al., 2016: 369). As such, those points above 1 will represent adzes which are thicker at the midpoint than they are wide. Those points below 1 represent adzes which are wider at the midpoint than they are tall.

The sample contains 192 shell and 83 stone adzes. Figure 12 displays the range, median, and interquartile ranges for the sample. The Thickness ratio of shell adzes ranges from .09 to 1.35, with a median of .46. The mean Thickness ratio for shell adzes is .49 ± .17 (Fig. 12). The Thickness ratio of stone adzes ranges from .37 to 2.39, with a median of .86. The mean Thickness ratio for the stone adzes is .90 ± .33. A Mann-Whitney U-test showed a significant difference between the stone and shell adzes ($p<.0001$, $u=1678$, $z=-10.39$). This, as with the previous graphs (Fig. 5, 6, 7, 9, 11), may describe some natural constraint of the materials between stone and shell adzes.

One extreme outlier to the interquartile range for stone adzes was specimen c6409 (Fig. 12a). This adze was particular in its construction, as reflected by the particularly high Thickness ratio. This adze constricted heavily towards the poll, with a large tang angle. Unfortunately, the edge and much of the body of this specimen was not present, as the adze was broken. Therefore, many of the other ratios which relied upon cutting edge and overall weight or length measurements were unable to be taken for this adze.

Figure 12a. Adze number c6409 (center). This adze, while unfortunately broken, exhibited a unique poll construction within the Tuamotus Adze Collection, most reminiscent of the Duff Type 5 side-hafted adzes.

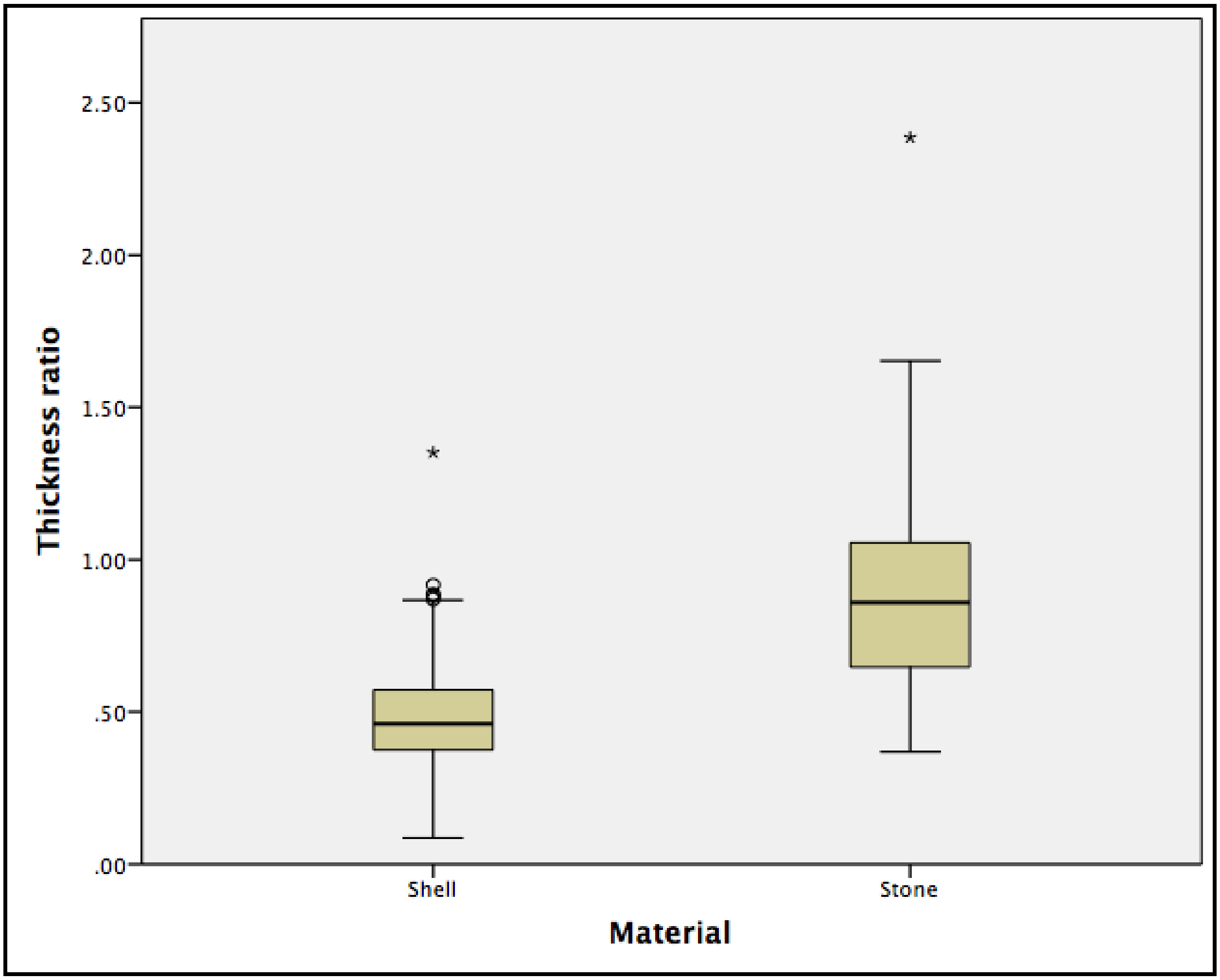

Figure 12. Thickness Ratio for shell (n=192) and stone (n=83) adzes from the Bishop Museum Tuamotus adze collection. The boxplot shows the median as the center line within the box (shell=.46, stone=.86). The range is shown by the spread of the full sample (shell=1.27, stone=2.02). Circles above the shell adze box plot show near outliers (1.5x the interquartile range); asterisks show far outliers (3x the interquartile range).

5.9 Edge Angle

Figure 13 displays the edge angles of the shell and stone adzes in the collection. This measurement was taken as the total angle of the cutting edge, measured as in Turner's (2000, 2005) analysis. According to Turner, the edge angle was one of the key characteristics which dictate the function of the adze (2005: 63). Amongst other factors, those adzes with similar edge angles can thus be assumed to have similar functions. Those adzes with broken or otherwise missing edges were removed from this analysis.

The sample contains 183 shell and 73 stone adzes. Figure 13 displays the range, median, and interquartile ranges for the sample. The edge angle of shell adzes ranges from 10 to 55, with a median of 30. The mean edge angle for shell adzes is 29.35 ± 8.67 (Fig. 13). The edge angle of stone adzes ranges from 8 to 75, with a median of 37. The mean edge angle for the stone adzes is 35.23 ± 13.02. Given Turner and Shipton et al.'s agreement regarding the functional importance of the cutting edge, the contrast between these plots strongly suggests a divide in function based on material type (Turner, 2000: 63, Shipton et al., 2016: 369). A Mann-Whitney U-test showed a significant difference between the stone and shell adzes ($p<.0001$, $u=5092$, $z=-3.36$).

Similar to the discussion of the attack ratio, the edge angle for an adze has been used to differentiate the types of tasks for which it may have been used. Those adzes with lower edge angles have been attributed to shaving and shaping tasks, while it is suggested that those with higher edge angles were used for heavier chopping, gouging, or chiseling tasks (Best, 1977: 312-315; Turner, 2005: 63-64; Shipton et al., 2016: 369). The distribution of edge angles for shell and stone adzes seem to reflect this divide along material types. Figure 13 shows a relatively tighter spread of edge angles for shell adzes as compared to stone. According to Best and Turner's experimental investigations, the lower cutting edge angles observed on many of the shell adzes indicate that these adzes would have been used for shaving and scraping tasks (Best, 1977: 315; Turner, 2005: 63-64).

Several shell adzes fell outside the interquartile range observed in Figure 13. These adzes, such as specimen c2963 (Fig. 10a), exhibited much higher cutting edge angles, and may indicate a difference in function between these adzes and the other shell adzes. Many of these outlying shell adzes also exhibited generally higher weights and were generally larger than the other shell adzes in the collection. These adzes with greater edge angles, according to Best and Turner's experiments, would have likely been used in a more axe or chisel-like manner, with deep gouging and chopping strikes (Best, 1977: 315; Turner, 2005: 63-64). This reflects more closely the inferred function for many of the stone adzes in this collection. The distribution of edge angles for stone adzes includes the entirety of the spread for shell adzes, as well as several higher edge angles. Thus, the interquartile range of stone adzes includes specimens that were appropriate for tasks both within and without the range of tasks for which the majority of shell adzes were specialized.

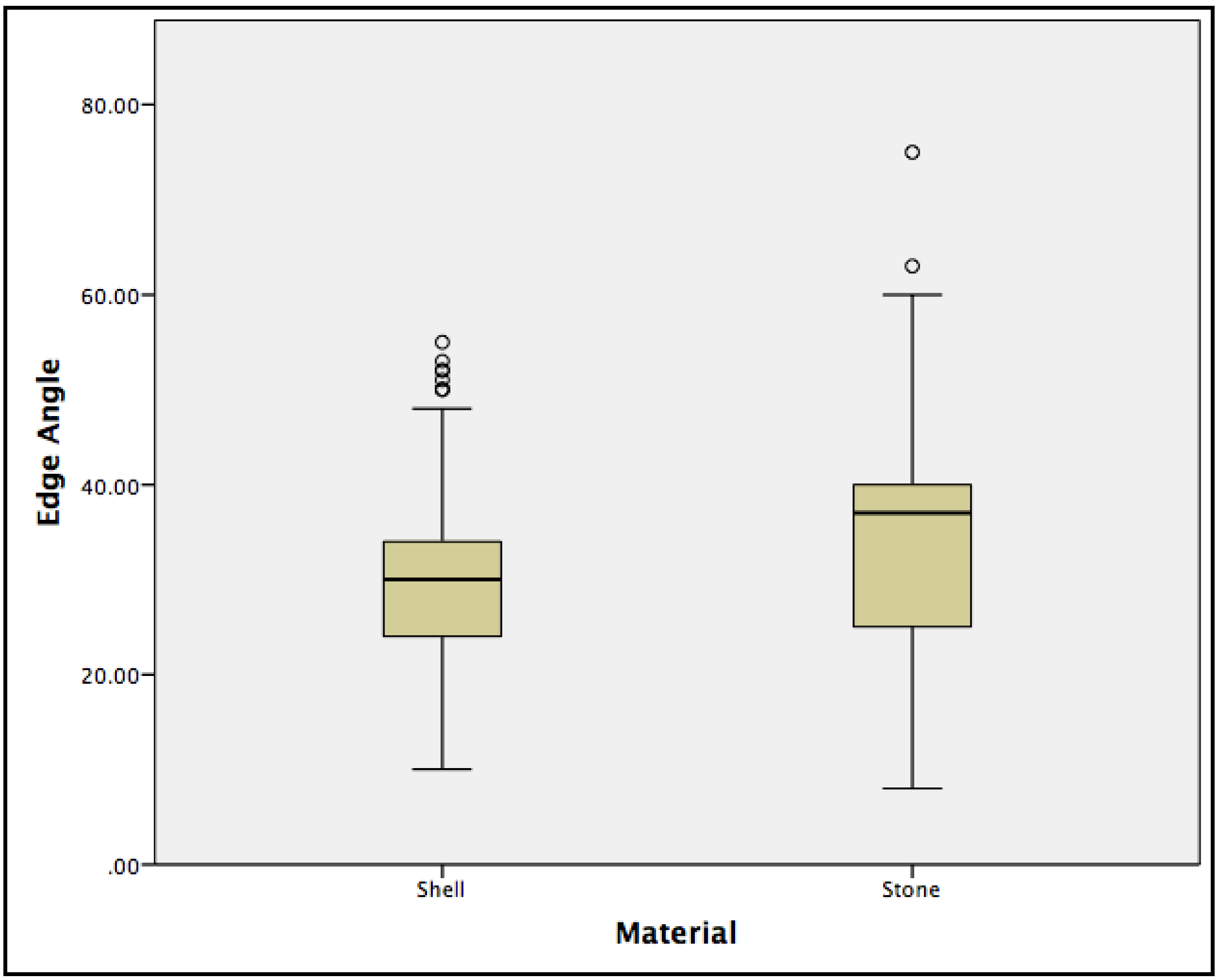

Figure 13, Edge Angle (degrees) for shell (n=183) and stone (n=73) adzes from the Bishop

Museum Tuamotus adze collection. The boxplot shows the median as the center line within the box (shell=30, stone=37). The range is shown by the spread of the full sample (shell=45, stone=67). Circles above the shell adze box plot show near outliers (1.5x the interquartile range); asterisks show far outliers (3x the interquartile range).

6. Discussion

Turner's (2000) functional types may prove an effective format for understanding the above differences in adze construction for the Tuamotus Adze Collection. Turner (2000) concluded that the Polynesian adze generally fell into one of four functional categories (Table 1). These types are separate and complementary in their function, and each type generally aligns with a different task. Of Turner's four categories, three were present within the Tuamotus Adze Collection. Turner's Type D, which includes side-hafted adzes, appears to only be represented by specimen number c6409 in this collection.

Turner's Type A adzes were generally used in shaving and shaping tasks, such as those associated with preparing planks and timbers, and would have been relatively lighter with a lower edge angle (2000: 453). Within the current study, this would be exhibited by lower Attack Ratios and lower cutting edge measurements. Turner's (2000) Type B adzes are designed for heavy chopping and splitting activities. As such, they generally exhibit wider cutting edges, high cutting edge angles, and a high Attack Ratio. These adzes would be necessary for the initial production of timber for the construction of various wood products, including canoes. Similarly, Turner's (2000) Type C adzes generally exhibit high cutting edge angles, varying Attack Ratios, and a narrow cutting edge. These adzes are necessary for any sort of gouging or chiseling tasks, and can vary in size and weight, dependent upon the environment in which the tool must be used (Turner, 2000: 453 – 454).

Functional analysis of the Tuamotus Adze Collection may indicate differences within the Tuamotus Adze Collection along the lines of material type and intended function. Combined with the geochemical evidence for such interactions and the ethnohistoric record, these observed differences may help to interpret prehistoric Central East Polynesian interactions from an archaeological and ethnohistorical point of view.

Best's (1977), Turner's (2000, 2005), and Shipton et al.'s (2016) discussions of functional attributes show the importance of adze weight, cutting edge width, and cutting edge angle to the function of a Polynesian adze. As such, the significant differences observed in the Attack Ratio and cutting edge angles between the stone and shell adzes suggest functional differences between the stone and shell adzes. The low Attack Ratio and cutting edge angle for the majority of shell adzes, such as specimen c2972 (Fig. 14) suggest that these adzes generally align with Turner's Type A: Timber Dressing Adzes (Turner, 2000: 453).

Figure 14. Adze number c2972 from the Tuamotus Adze Collection. The low Attack Ratio and angle of the Cutting Edge reflect the characteristics common among Turner's (2000) Type A Adzes.

The shell adzes in this collection do not universally fall into Turner's Type A category. Several outliers to the Attack Ratio and the cutting edge angle were observed in the sample of shell adzes. Those shell adzes which fell above the interquartile range for the cutting edge angle (fig. 13), also generally fell above the interquartile range for the Attack Ratio (fig. 10). These outlying adzes, such as specimen c2963 (Fig. 10a), would have largely fit Turner's Type B: Wood Splitting and Chopping category. These adzes, according to Turner, generally exhibit higher cutting edge angles, greater weights, and wider cutting edges (Turner, 2000: 453 – 454). Such characteristics make these adzes favorable for heavier chopping and gouging activities critical to the initial preparation of timber for planking and other uses. However, shell adzes exhibiting these characteristics are comparatively rare in the Tuamotus Adze Collection. Only 13 of the 192 shell adzes examined showed these characteristics, totally roughly 6%. As such, shell adzes with these characteristics seem to be exceptions, rather than the rule.

In contrast, the general patterns for stone adzes in the Tuamotus Adze Collection include several of Turner's (2000) functional types. Several stone adzes, such as specimen c7727 (Fig. 15) exhibit the low Attack Ratio and cutting edge angle important for Turner's Type A. Others, such as specimen c9229 (Fig. 16) seem to align more closely with the high Attack Ratio, high adze weight, and high cutting edge angle important for the tasks accomplished by Turner's Type B adzes. Still other stone adzes, such as specimen c2367 (Fig. 17) exhibited high Attack Ratios, cutting edge angles, and low cutting edge widths necessary for the completion of tasks associated with Turner's Type C adzes.

Figure 15. Adze number c7727 from the Tuamotus Adze Collection. One of several stone adzes from the collection which exhibited the generally low Attack Ratios and cutting edge angles common for Turner's (2000) Type A Adzes.

Figure 16. Adze number 9229 from the Tuamotus Adze Collection. The high weight, Attack Ratio, cutting edge angle, and cutting edge width for this adze suggests that it is closely aligned with Turner's (2000) Type B Adzes.

Figure 17. Adze number c2367 from the Tuamotus Adze Collection. Note the high cutting edge angle and relatively low cutting edge width. Combined with a high Attack Ratio, this allows the adze to complete tasks associated with Turner's (2000) Type C Adzes.

The analysis of the shell adzes in the Tuamotus Adze Collection seems to show a general preference for Turner's Type A adzes. While several outlying shell adzes did seem to conform to Turner's Type B, these adzes were outliers with regards to both Attack Ratio and cutting edge angles. Rather, the majority of shell adzes generally fit within the low Attack Ratio and low cutting edge angle exhibited by Turner's Type A adzes. The Type A adzes, according to Turner (2000) and Best's (1977) research, are generally unsuitable for several important woodworking tasks, particularly those requiring heavier implements or higher cutting edge angles, such as chopping.

Because those shell adzes which conformed to Turner's Type B characteristics were outliers to the general pattern exhibited by the majority of shell adzes, this might be interpreted as a preference of the Tuamotuan artisans. Knowing the natural constraints of *Tridacna* and *Cassis* shell, the Tuamotuans appear to have generally utilized these materials for tasks that required less direct force, such as shaving and chipping. The stone adzes examined in this study, then, appear to complement this preference. The stone adzes examined here exhibit characteristics common to Turner's A, B, and C Types (Turner, 2000: 453 – 454). Based on the Attack Ratio results, roughly 26% of the stone adzes examined fell within the interquartile range for shell adzes, suggesting a similar function to these Type A adzes. The remaining 74% of the adzes were largely split between Types B and C, with approximately 7% of these adzes suitable for the chiseling tasks of Type C. The flexibility afforded the artisan by the natural morphology of the basalt, combined with the greater weight and durability of the material as compared to *Tridacna* or *Cassis* shell, likely allowed the artisan to shape adzes to address a wider variety of tasks.

Given the ethnohistoric evidence for close contact between the Tuamotus and the Society Islands through the late pre-contact and early historic periods, it is likely that the prehistoric Tuamotuan peoples specifically imported stone adzes to complement the supply of locally produced shell adzes. Knowing that adzes of shell were particularly suited to a certain number of tasks, particularly those related to shaving and light scraping, the prehistoric inhabitants of the region would have incentive to procure high-quality basalt from elsewhere. The basalt adzes procured in this manner would have filled the functional requirements of the shipwrights, by supplying them with the ability to better fulfill the heavier chopping, splitting, and gouging activities necessary in canoe construction.

The differences observed in function between the stone and shell adzes may have been a factor in encouraging contact between the Tuamotu atolls and the rest of Central East Polynesia. Based on Collerson and Weisler's 2007 study, it is clear that there was contact between the Tuamotus and the Society, Marquesan, Austral, Pitcairn, and Hawaiian island chains (Collerson and Weisler, 2007: 1907-1909). Further, functional analysis of these and other stone adzes collected in the Tuamotus suggest that this contact between the Tuamotus and the high volcanic island chains may have in part been due to a need for high-quality basalt with which to make specialized adzes. However, the relatively small sample size of adzes sourced via geochemical analysis as well as the limited number of stone adzes within the collection problematizes estimates of regional origin for the basalt adzes. Further geochemical studies of the Tuamotus collection could reveal more information regarding the contact between the Tuamotu atolls and the rest of Central East Polynesia.

The ethnohistoric record helps to illuminate the extent and nature of the interactions proposed by Collerson and Weisler. The various interactions recorded at or shortly after contact between the Society Islands and the Tuamotus hint at the possibility of more robust contact in the prehistoric period. Oliver’s (1974) work gives several examples of goods, particularly pearl shell and plaitware mats, being regularly traded between the Tuamotus and the Society Islands (1974: 138, 151, 194). Other works, such as Finney’s (1994), note that contact occurred between the northern Tuamotus atolls and the Marquesas Islands throughout prehistory (1994: 284). Haddon and Hornell’s (1936) work provides a final clue to the nature of interaction between the Tuamotus and the Society Islands. In this work, the Haddon and Hornell combine several early historic accounts of the Tahitian and Tuamotuan canoes and the process by which they were constructed. According to these early reports, the Tuamotuans were frequently employed as master shipwrights by the Tahitians, and whose skills were highly sought (1936: 79, 83, 91, 137). Such records, combined with the archaeological evidence presented in this and other works, may indicate long-standing interactions between the Tuamotus and the Society Islands, wherein specialists and goods from the archipelagoes played important roles in the construction and maintenance of maritime interaction spheres.

7. Conclusions

The application of a functional analysis to the Tuamotus adze collection has revealed two important points regarding the production and use of adzes within the Tuamotus. First, the author asserts that the restrictions in raw material present in *Tridacna* and *Cassis* shell adzes largely dictate the amount of influence the artisan can exert over the final morphology of the tool. This is supported by the Back-Front Width and Side-Mid Thickness ratios from Shipton et al.'s work. Statistical tests of the shell and stone sample showed a significant difference between the adzes based on material type for several functional attributes. While the stone adzes could be shaped largely at will by the artisan, the shell adzes were highly constricted based on the morphology of the original material.

Second, the analysis of functional characteristics for the adzes such as the Attack Ratio and cutting edge angle show significant differences between the stone and shell adzes. Statistical tests conducted on the Attack Ratio and cutting edge angle show significant differences between the stone and shell adzes. These differences are supported by the conclusions of previous experimental and functional studies (Best, 1977; Turner 2000; Turner, 2005). Based on the similarities in cutting edge angle and Attack Ratio the shell adzes sampled appear to have primarily been used for shaving, shaping, and other similar tasks, in line with Turner's (2000) functional Type A. The stone adzes examined within the Tuamotus Adze Collection exhibited characteristics in line with Turner's Type A, B, and C categories. While some shell adzes also fit within Turner's Type B adzes, these were the exception, rather than the rule. As such, it is likely that the basalt adzes were specifically imported from elsewhere in Central East Polynesia to complement the shell tools created from naturally occurring resources in the Tuamotus, as each of these functional types are critical in the shipbuilding process.

These observations complement both earlier archaeological and ethnohistorical research into prehistoric Central East Polynesian interactions. The complementary nature of the Tuamotuan adze kit articulates with ethnohistoric evidence for interaction between the Tuamotus and the Society Islands. This interaction, while likely involving far more than simply the exchange of goods and expertise between the Society and Tuamotu Islands, would have been critical to the maintenance of the shipbuilding industry present within the Tuamotus, as it supplied necessary material with which to create the multiple tool types that are required for the construction of voyaging canoes. Further research, incorporating temporal information to the functional and technological analysis of artifacts from the Tuamotus, might indicate the extent to which this interaction took place throughout Central East Polynesian pre- and protohistory.

References Cited

Alkire, W., 1965. *Lamotreck Atoll: Inter-island Socioeconmic Ties*. Waveland Press, Prospect Heights, IL.

Allen, M., 2014. Marquesan Colonisation Chronologies and Postcolonisation Interaction: Implications for Hawaiian origins and the 'Marquesan Homeland' hypothesis. *The Journal of Pacific Archaeology* 5, 2:1-17.

Best, S., 1977. The Maori Adze: An Explanation for Change. *The Journal of the Polynesian Society* 86, 3:307-338.

Best, S., Sheppard, P., Green, R., Parker, R., 1992. Necromancing the Stone: Archaeologists and Adzes in Samoa. *The Journal of the Polynesian Society* 101, 1:45-85.

Buck, P. 1938. *Vikings of the Sunrise*. Stokes, New York.

Collerson, K. D., Weisler, M., 2007. Stone Adze Compositions and the Extent of Ancient Polynesian Voyaging and Trade. *Science* 317:1907-1911.

Davidson, J.M., 1961. A Guide to the Description of Adzes. *New Zealand Archaeological Association Newsletter* 4:6–10.

Duff, R.S., 1959. Neolithic Adzes of Eastern Polynesia. J. Freeman, W. Geddes, H. Skinner, eds., Anthropology *of the South Seas, Essays Presented to H D Skinner*. Plymouth, 121-147.

Dunnel, R. C., 1971. *Systematics in Prehistory*. The Free Press, A division of MacMillan Publishing. New York, NY.

Dunnel, R. C., 1978. Style and Function: A Fundamental Dichotomy. *American Antiquity* 43, 2:192-202.

Ellis, W., 1829. *Polynesian Researches.* Volume 2. Fisher, Son, and Jackson. London.

Emory, K. P., 1975. *Material Culture in the Tuamotu Archipelago*. Bernice Pauahi Bishop Museum. Honolulu, HI.

Finney, B. 1994. *Voyage of Rediscovery: A Cultural Odyssey Through Polynesia*. University of California Press, Berkeley.

Garranger, J., 1972. Herminettes Lithiques Oceaniennes: Elementes de Typologie. *Journal de la Societe des Oceanistes*. 28:253-274.

Green, R., 1970. Evidence for the Development of the Early Polynesian Adze Kit. *New Zealand Archaeological Association Newsletter*. 12-44.

Gessler, C., 1937. *Road My Body Goes*. Reynal and Hitchcock, New York.

Haddon, A.C., Hornell, J., 1936. *Canoes of Oceania*. Bishop Museum Press, Honolulu.

Kahn, J., Sinton, J., Mills, P., Lundblad, S., 2012. X-ray Fluorescence Analysis and Intra-island Exchange in the Society Island Archipelago. *Journal of Archaeological Science*. 40:1194-1202.

Kahn, J. G., Dye, T., 2015. A Note on Hawaiian Stone Axes. *Journal of Pacific Archaeology* 6, 1:18-25.

Leach, H.M., Leach, B.F., 1980. The Riverton Site: An Archaic Adze Manufactory in Western Southland, New Zealand. *New Zealand Journal of Archaeology*. 2:99-140.

McAlister, A., Sheppard, P., Allen, M., 2013. The Identification of a Marquesan Adze in the Cook Islands. *The Journal of the Polynesian Society* 122, 3:257-273.

Moerenhout, J., 1837. *Voyage aux îles du Grand Océan.* Adrien Maisonneuve. Paris.

Morrison, J. 1935. *The Journal of James Morrison, Boatswain's Mate of the Bounty, Describing the Mutiny and Subsequent Misfortunes of the Mutineers, together with an Account of the Island of Tahiti*. Edited by Owen Rutter. The Golden Cockerel Press. London.

Oliver, D., 1974. *Ancient Tahitian Society*. Vol. 1 and 2. The University Press of Hawaii, Honolulu.

Quiros, P. F., 1904. *The Voyages of Pedro Fernandez de Quiros, 1595-1606*. Translated and Edited by Clements Marham. Hakluyt Society. London

Reith, T., Cochrane, E., 2015. The Chronology of Colonization in Remote Oceania. In *The Oxford Handbook of Prehistoric Oceania*. Oxford University Press, Oxford.

Rolett, B. V., 1998. *Hanamiai: Prehistoric Colonization and Cultural Change in the Marquesas Islands (East Polynesia)*. Yale University Publications in Anthropology. Yale University.

Rolett, B. V., 2002. Voyaging and Interaction in Ancient East Polynesia. *Asian Perspectives* 41, 2:182-194.

Rolett, B. V., West, E., Sinton, J., Iovita, R., 2015. Ancient East Polynesian Voyaging Spheres: New evidence from the Vitaria Adze Quarry. *Journal of Archaeological Science* 53:459-471.

Rosendahl, P.H., 1969. Micronesian Shell Adzes: A Preliminary Terminology and Classification. Ms. on file in the Department of Anthropology, Bishop Museum. Honolulu.

Shipton, C., Weisler, M., Jacomb, C., Clarkson, C., Walter, R., 2016 .A Morphometric Reassessment of Roger Duff's Polynesian Adze Typology. *Journal of Archaeological Science*. Reports 6: 361-375.

Skinner, H.D., 1943. The Classification of Greywacke and Nephrite Adzes from Murihiku, NZ. *The Journal of the Polynesian Society* 52, 2:65-85.

Turner, M. T., 2000. *The Function, Design, and Distribution of New Zealand*. University of Auckland Press.

Turner, M. T., 2005. Functional and Technological Explanations for the Variation Among Early New Zealand Adzes. *New Zealand Journal of Archaeology* 26:57-101.

Weisler, M., Kirch, P., 1996. Interisland and Interarchipelago Transfer of Stone Tools in Prehistoric Polynesia. *Proceedings of the National Academy of Sciences of the United States of America* 93, 4:1381-1385).

Weisler, M. 1998. Hard Evidence for Prehistoric Interaction in Polynesia. *Current Anthropology* 39, 4:521-532.

Weisler, M., 2002. Centrality and the Collapse of Long-Distance Voyaging in East Polynesia. *Geochemical Evidence for Long-Distance Exchange*. Bergin and Garvey, London, 257-273.

Wilmshurst, J. M., Hunt, T., Lipo, C., Anderson, A., 2011. High-precision radiocarbon dating shows recent and rapid initial human colonization of East Polynesia. *Proceedings of the National Academy of Sciences* 108, 5:1815-1820.